THE SPLENDID BOOK OF ENGINEERING

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THE SPLENDID BOOK OF ENGINEERING

BY

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THE SPLENDID BOOK OF ENGINEERING

I

FAMOUS BRIDGES

The completion of the great bridge over Sydney Harbour marks the end of one of the greatest engineering ventures of the present century. The authorities would not agree to a bridge with less than a single span as it was desired to preserve that wonderful entrance to one of the finest harbours in the world.

The contract for the bridge was secured by the famous firm of Dorman, Long & Co., of Middlesborough, in the face of stern competition. The total cost of the bridge and its approach roads is not less than £6,000,000. The total length of the main

bridge is 3,770 feet, and no less than 50,000 tons of steel have been employed in the main structure.

The two halves were built slowly outwards from either side and for six years they were growing—either in the form of steel plates and girders in the making, or in being placed in position, until, in 1930, the connecting link was made in an arch which had a span of 1,650 feet. The arch rises to a height of 410 feet, and there is always a headway of 170 feet at high water, and considerably more at low tide, thus the biggest steamship can enter without waiting outside for the tide to fall.

The bridge carries four lines of standard-gauge railway, a roadway 57 feet wide, with two footways each 10 feet wide. It is estimated that the maximum capacity of the bridge will be 168 electric trains, 6,000 vehicles, and 40,000 foot passengers an hour—remarkable figures these. The bridge is due to be opened for traffic in 1932.

The Romans probably built the first bridge across the Tyne something like eighteen

hundred years ago. We do not quite know how they bridged the river, but from details of other similar structures of the Romans, which have come down to us, it is shown that they usually drove piles into the river bed on which stone piers were built, and then a timber bridge was thrown across from pier to pier.

For hundreds of years there was a bridge with houses upon it, but this became unsafe, and a nine-arch bridge was constructed in 1871; this, however, so seriously affected the traffic up and down the river that it was superseded by a swing bridge.

In the 'forties Robert Stephenson had to bridge the Tyne at Newcastle in order to carry the railway across it. It was decided to have a high-level bridge with rail and road facilities. This gave Stephenson a great deal of trouble as there was difficulty in securing good foundations for such a huge structure.

The traffic is so great across the Tyne that another bridge was needed, and the present single-span bridge was decided upon,

Dorman, Long & Co., the celebrated bridge builders of Middlesborough, being awarded the contract.

The most interesting feature of the Newcastle bridge is the fact that it produces, in miniature, the wonderful structure which Dorman, Long & Co. have so successfully thrown across the huge harbour at Sydney. The Tyne bridge is almost exactly a third the span of the Sydney structure. The former provides two lines for trams, four for vehicular traffic besides two footways of considerable width.

The magnificent single-span arch is approached by spans on either side of the river which total 719 feet, the actual arch of the bridge being 531 feet, and is, therefore, easily the largest arch in this country. The greatest height of the arch is 170 feet and the roadway is rather more than half that height above the river level at high tide.

The steelwork of the structure weighs about 8,000 tons, approximately half of it going into the arch and the roadway which

it supports. Rarely has such a safe bridge as this been built. Too often in the past the engineers considered the loads then current and paid no attention to those likely in the future. Here the designers looked ahead indeed and if 100 tons can be safely placed on four wheels that magnificent bridge will take it.

In order to balance the arch there are two very handsome granite abutment towers. Here the skill of the steel worker is concealed, but it is there nevertheless, for the towers are really of steel, cased in with granite, to give a handsome appearance, and to provide the weight necessary to counterpoise that enormous thrust of the single arch. The towers cover a good deal of floor space, and in addition to providing means for passengers ascending from the quays to the bridge, they are adapted for use for warehousing goods.

As in most of these structures, the work went on from both sides of the river, the men building outwards at what seemed a dizzy height to the people below. Gradually

the two arms approached each other until they could be joined.

One of the greatest bridges erected in recent years is that which spans the harbour of Montreal. Four million pounds has been spent on the bridge. The biggest liners can pass under it quite easily, whilst its floor accommodates four lines of vehicular traffic, provides side walks for foot passengers, and two tramway tracks are also arranged on the outside of the central vehicular road. Two main piers carry the principal span, which is no less than 1,097 feet, with a height of 162 feet above water level at the highest point of the tide. This portion is a cantilever structure with two 420-feet anchor arms. Thirteen steel towers and two masonry piers carry the rest of the bridge. There are many steel spans over that portion of the St. Lawrence which is shallow and not used for traffic; these vary from 90 to 245 feet in length.

The Montreal Harbour Bridge is one of the world's greatest, whether considered from the point of view of importance or

length; it forms a most valuable link, yet, like our own Charing Cross Bridge, it has been the subject of much debate and delay in building. From end to end the bridge is quite two miles, and it brings the growing district south of the city into direct touch with it.

Some thousands of tons of silicon and carbon steel have been incorporated in what is a splendid monument to both the designer and the builders.

It seems almost incredible to old-time railway travellers that the majestic Forth Bridge is well on its way to celebrating its jubilee. It seems only the other day that they were having to turn out of their train—perhaps on a cold winter's night, and take the steam ferry over a stretch of water which could be singularly vicious at times.

If the ferry were to be avoided a distance of something like seventy miles had to be travelled by rail instead of twenty of to-day, so obviously there was a case for a bridge here if it could be built.

Many schemes had been started, but somehow there were always objections, and some of them were too well-founded. Bouch had built a bridge across the Tay, and encouraged by what he thought was a very successful venture, he went on to prepare plans for the Forth Bridge. Fortunately they were never persisted in, or perhaps the same fate would have awaited the greater bridge. It will be remembered that the Tay Bridge collapsed during a gale and took a train and seventy people with it to the river below. Actually the Forth Bridge had been begun, when the collapse of that over the Tay brought everything to a standstill, and caused people to shake their heads and say that the task was beyond the engineer.

The original Forth Bridge was being undertaken by the North British Railway Co. who wanted to shorten their route to the north, but when the new venture was considered it became apparent that several railways would benefit, and therefore they should take their share in making the scheme

Newcastle Bridge, Gateshead Arch
Many Bridges are now Built on this Great Arch Principle

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QUEBEC BRIDGE [*By courtesy Canadian National Railways*

This Huge Bridge Spans the St. Lawrence River

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a success. In the 'eighties a scheme was submitted by Fowler & Baker, which seemed to meet all objections, and the work was sanctioned, though not before several rival schemes had been considered and turned down. It seemed obvious to the assessors that the only kind of structure which would meet all objections was one of the cantilever type. This meant a steel bridge, with a great height, in order that a warship, with her towering masts, could go safely below it. There were two deep water channels to be left unobstructed, and over these came the greatest spans, each of 1,710 feet; in addition, there were two other spans each of 689¾ feet. In addition to these there were fifteen short approach spans to the four greater ones; these were of 168 feet each, resting on granite piers. Then, to give access to these, came four granite arch spans of 57 feet each, and finally four of 25 feet each. Adding the total spans together the huge length of 2,765 yards is obtained, thus constituting the greatest bridge in these islands, and one

which was to set the fashion for many greater ones in the world of railways overseas.

In assessing the Forth Bridge the granite and shorter spans are frequently overlooked, but one has only to stand beneath the preliminary spans to realise that if they were not so completely dwarfed by those huge cantilevers nearer the centre of the bridge, they would be acclaimed as wondrous indeed.

Possibly owing to the failure of the Tay Bridge, the Bill for the greater structure was only obtained after a severe struggle, and finally the big contract was awarded to a firm formed specially for the undertaking; this was known as Tancred, Arrol & Co. There was no time lost in making a start upon the venture. The Act was obtained in 1882; in January of the following year a beginning was made. For more than seven years work went ahead as speedily as possible, due regard being had to the delays incidental from rough and winter weather. Never before in Great Britain had

a bridge been undertaken on the lines chosen for the Forth.

The caissons gave some trouble. They had to be floated out and moored in the fairway. This was a ticklish proceeding, and one of them filled and sank through water entering the rivet holes. It tilted out of the vertical, and it took nine months to get it back again. Such a mishap as this not only held up the progress of the work but it involved unneccessary expense. Apart from the misfortune with the caisson no serious delay was experienced.

Slowly the great arms stretched out towards each other and, as the yards lessened which divided the north from the south side, the workmen entered fully into the race for the honour of the first crossing. The work had been proceeding vigorously in the late 'eighties from both sides, and by the autumn there were only two narrow gaps to be joined up. As September, 1889, drew to its close there was a matter of mere feet dividing each of the two big spans. Who should have the honour of going first

dry-shod over the Forth? Obviously it would be one of the workmen and well he deserved that honour.

Two of them at length hit upon the plan of throwing a ladder across the abyss; one went to fetch a rope, with which to secure the ladder in position. Whilst he was gone, the other fellow, risking a terrible death, actually tripped over the insecure ladder, the waters of the Forth showing only too plainly through the open spokes. Two days passed and visitors had followed less perilously, and then on the 10th of October the gap was filled in such a manner that anyone might venture the crossing.

It should be made clear that there was still a gap between the ends of the two portions comprising the north centre girder. This made a break of 60 feet in the entire structure. It was filled on the 15th of October, so that within a month the east and west were joined throughout, and many visitors made the complete crossing.

In January, 1890, the bridge was practically complete, and to test it thoroughly two goods trains, weighing with their engines no less than 1,800 tons, were run into the centre of the bridge, and there left for a time for a thorough testing. If the bridge would show no deviation from truth with such a load as this it was obvious that it could be opened for traffic within a short time. For some reason it was not deemed advisable to run these goods trains right across from side to side, but three days later—on the 24th of January—a passenger train with the directors, friends and staff crossed safely, the locomotive being driven by the Marchioness of Tweeddale. Followed the official tests by the Board of Trade during the middle portion of February, and then came the official opening by the Prince of Wales, later King Edward the Seventh.

In this great bridge there are 52,250 tons of steel and thousands of tons of masonry. The whole of the metal-work requires repainting once in three years, and to enable

it to be carried out systematically a permanent staff of painters is employed sufficient to deal with a third of the steel-work each year. Could the metal be flattened out it would equal an area of 135 acres; this represents the area which the painters must cover.

II

LIGHTING LONDON

HAVE you ever thought of the problem and the solution of it which is involved in the lighting of London? Not only must there be light for all when night closes in, but the hours when fog blocks out the daylight in London really add many more nights to the 365 of the normal year. Apart from gas and candles—and the former still plays a very great part in lighting the poorer homes—there are many great power stations scattered in and around the metropolis which must always keep efficient, whose breakdown, if only for a few minutes, involves the users of the current in great losses.

At the moment the greatest of the power stations around London is that which has

been built at Barking. It has been placed so far out of the city for many reasons; first, on account of the smoke which can be blown to sea, or over Essex rather than the city; secondly, because land is much cheaper; thirdly, because by placing it on the banks of the Thames colliers can bring 3,000 tons of coal at a time to feed those hungry furnaces. These eat up at least 70 tons an hour when in full action, and remember that economical combustion under the most approved system possible will secure far more steam per ton than twenty years ago.

Barking is not only the biggest power station in Britain but, when the projected extensions are carried out, it will be the greatest in the world. Although it has been mentioned that it supplies a portion of London's needs, it is really the power house for a good many of the Home Counties and the extensions will mean an addition of a very much greater area to its already large tract of country.

To-day Barking is producing current

representing something like 320,000 horse-power each twice round of the clock.

Here we have organisation brought to a very high state of perfection, and there are many who think that this kind of organisation is what is wanted in every industry, and that all industries must work on the big scale or not at all. Thus everything which can be done by a machine is accomplished in that fashion. The colliers, for instance, which a few years ago would have been unloaded laboriously by hand labour, are discharged by machinery which is almost human in its sagacity.

Working steadily the mechanical unloaders take out the coal from every nook and cranny in the collier's hold, pass it along to some splendid machinery which quickly reduces it to a powder. The pulverised fuel can then be fed to the boilers by machinery which, in many respects, resembles that which feeds the boilers of an ocean liner with oil. There is no waste with pulverised coal, and no clinker to clog up the firebars.

But perhaps the strangest touch of all is found at an intermediate point where a clever device is employed to sample the coal. The samples are taken as desired and go to the laboratory where the usual analytical tests are made to determine whether the fuel is the best that can be supplied for the pulverisers.

Another great advantage of the riverside situation of the huge power station is the fact that water does not have to be paid for from any waterworks; this is an expensive item when something like a constant stream, running into millions of gallons a day, is a prime need of the boilers and condensers.

It is no light task pumping up a stream which would fill continuously a pipe with a diameter of eight feet. In addition, something has to be done to this water for the sake of the boilers, which object strongly to any suspended matter in their supply. Here again the scientist comes to the aid of the engineer. The latter has erected and equipped a small building in

which the apparatus suggested by the scientist is installed.

This is designed to impregnate the water with a solution of chlorine gas. This is such a powerful agent for the work in view that only one part of the gas is required to two million parts of water. The marvel of the apparatus is that without any intervention on the part of the men in charge this impregnation goes on continuously and always in the correct proportions.

Come to the boiler houses for a moment and there see something which is well worth while. There is little noise in those vast houses; there are several. No constant clanging of furnace doors, no opening and shutting, no raking out, no shovelling of coal to an insatiable giant. It is all done by machinery and the pulverised coal streams along and into the furnace. In order that the men in charge—or the visitor—may see what is going forward there is a small eye through which the interior of the inferno may be watched—but only through tinted

glasses, so great is the glare of that consuming fuel.

In the older power houses there are huge vertical or horizontal engines, clanging their way through life. At Barking the turbine has attained its zenith, for here is a whole army of these excellent machines which work so efficiently and yet so silently. There is just the low drone and no sense—or little sense—of movement beyond the drone.

From the turbine house to the power house is an easy step and here that great genii is fully enthroned—that magician which can be so excellent a servant, so terrible a master. That rebellion is possible and anticipated is explained by the guide, who states that in order to provide for any eventuality the power house can be flooded instantly with a curious gas which has the merit of beating fire.

But such a gas is, like the electric generators, a good servant but a terrible master. For this reason there is a gas mask always kept ready so that if it

should be necessary to call in this ally he shall not be an enemy to the fellow whose job it is to see that all is clear, and that no engineer has been overlooked and overcome by the fumes of that potent gas.

Passing on we come next to a room where there are many graphs and charts, discs and other tell-tale adjuncts of a great power station.

By these charts the engineers in charge are able to gauge the requirements of every hour of the twenty-four. They tell a story of great demands on the current and the story is a rather different one each day of the year, since as the days lengthen the consumption naturally drops from five onwards to nightfall and the graph shows, too, how the mornings are affected. But it is not only light which has to be considered.

Up-to-date factories are relying more and more upon power taken from such a station as this. And there is the housewife who does her cooking. There is a decided upward

trend when the hour of the midday meal comes along, whilst a cold snap in March will certainly have a pointed effect on consumption.

Yet the midday rise and fall shows some strange changes at certain parts of an hour, and they are explained by the guide who says that, whilst there is the demand for cooking just before one, there is a corresponding drop at that hour from the factories and offices because thousands of lights necessary in basements and badly built upper rooms are turned off.

A question to the guide is, " How is the current sent to the south side of the river where most of it is used? "

" Wait and see," is the reply, and sure enough the mystery is soon cleared up. Barking power house has its own private tunnel, driven well and deeply under the great river. Down it go many serpents—that is the best simile perhaps for the numerous rather bloated cables which worm their way from north to south whilst great ships pass over them. One is left wondering

what would happen did the current escape by some means from a well charged cable to the steel bottom of some unfortunate ship passing only a few feet above.

Mention has been made already of the careful organisation and the introduction of labour saving machinery at Barking. It is a vast place doing national work with the minimum amount of labour. An inquiry elicited the fact that there are only about five hundred men employed there. Yet it is so vast and does so much. Think of the horse-power developed and distributed every day!

Such organisations as these explain very trenchantly the growing list of the unemployed. Yet here is the paradox, for whilst there are far less men found work at Barking than would be the case if the equipment were say, twenty years old, the cheapness of the product induces a greater use of the current, which in turn encourages manufacturers to extend their works and give greater employment. So there are always wheels within wheels, and what is lost on

the horses is amply made up on the swing-boats of industry.

If Britain is to continue great, and a workshop for many parts of the world, it is such organisations as Barking which will allow of it being accomplished.

[By Courtesy G.W.R.

SEVERN TUNNEL, WELSH ENTRANCE
Britain's Longest Tunnel

[*Face page* 32

[By courtesy of the Metropolitan Railway

CONSTRUCTING THE METROPOLITAN RAILWAY
A Cutting was Made and then Covered Over

Face page 33]

III

A LOCOMOTIVE THAT FEEDS ITSELF

THAT is a rather far-fetched title to give to the new self-trimming tender for locomotives which the well known locomotive builders, Messrs. Beyer, Peacock & Co., of Manchester, have recently introduced. But any fireman who had sweated at the shovel, and then had to work backwards as much as twenty feet to get at his coal in a fast-emptying tender, would agree that the new tender at least placed the locomotive's food within easy reach of that insatiable mouth—the furnace door.

It will be found that the ordinary kind of tender is employed, but that a rounded tank arrangement, with several doors, is placed where the coal is usually found. These doors allow of the fuel being shot into the big circular hopper, which is built

on a tapering system to help the coal in its travel from back to front of the tender.

But this would not operate satisfactorily of itself, especially when we remember that an engine must often run tender first for some considerable distances. Hidden away in the interior of the circular container is a series of small engines, whose business it is to work the coal forward so that the fireman has always a supply within arm's length.

Unfortunately, the movement of the train with its vibration tends to congeal the fuel into a more or less solid mass, and this factor had to be considered. The clever designer of the self-trimming tender got over his difficulty by making the machinery hidden in the container produce a complete turn round; that is to say the container will rotate upon steam being admitted to a certain valve. This shakes up the coal and allows the pushing forward screws to continue their good work.

Although the builders had in view the helping of the fireman on their big Beyer-Garratt articulated engines (as now seen often on the L.M.S. and the L.N.E.R.), where there are virtually two engines in one, needing a very big boiler and therefore plenty of fuel, the new container can be fitted to most existing tenders.

The fireman's job has become increasingly heavy during the last few years owing to the tremendous growth in the locomotive boiler, and it has meant not only extra work for him, but less assistance from him to the driver. Obviously the man with the shovel constantly in his hand could not give that expected look-out for signals which every fireman is enjoined to give. As signals tend to become more complicated and traffic, on the main lines at any rate, is still growing, it will be appreciated that the relief given to the fireman by the new self-trimming tender will be of real use to the driver besides making his chum's work far less arduous.

One of the new tenders is fitted experimentally to a new Beyer-Garratt goods engine now at work on the L.M.S., one of thirty-three of this type of locomotive now in service on our greatest railway.

IV

TUNNELS AND THEIR MAKING

Tunnels provide the engineer with one of his most fascinating problems. Boring through a hill or mountain is quite an adventure because one can never be quite sure what will be found ahead of the cutting plant. Over and over again an underground and quite unsuspected spring has been encountered; indeed, it would be accurate to call it a river. A preliminary survey and a trial shaft may show that the job is going to be an easy one, but too often it has been the case that the shaft missed a strata of the hardest rock imaginable, rock which will dull the sharpest cutting machinery, and which will probably need a powerful explosive to get a way through it.

Perhaps of all things feared by the engineer engaged upon tunnelling is the

unsuspected presence of a spring. The small spring can be diverted, if not drained, but there are many instances in which all calculations have been upset, lives lost or endangered, and huge losses sustained through an aggressive spring. Even when it has been conquered, and the tunnel made, it is by no means certain that trouble will not be constant as long as the tunnel lasts. In such cases expensive pumping machinery will have to be installed whilst the wages and upkeep of the plant will run to thousands a year.

Stephenson, when engaged upon the survey of the London and Birmingham railway, the first of our great trunk lines, planned its course to take in Northampton, incidentally avoiding a good many cuttings and a tunnel to get through a range of foot-hills.

Unfortunately for Stephenson—and for Northampton as it turned out—intense opposition was encountered from the land-owners round that town. They did not want the railway and preferred to be served

by the stage coach! There was only one thing for it—Stephenson had to make a fresh survey, leaving Northampton on one side and cutting through the hills he had so keenly desired to miss, for "Old George" dearly loved a well-graded line, and he realised that deep cuttings and a tunnel to keep it anything on the level he desired would add greatly to an already heavy expenditure.

But he could not have foreseen that an underground river (by some called a spring), would be tapped at Kilsby, and that the contractor who offered to bore the tunnel and line it for a sum of less than £100,000 would be ruined and so worried that he died under the strain.

It was necessary to go on with the boring, but so difficult was this problem of water, sufficient being pumped out daily to supply the needs of a fairly large town, that over £300,000 was expended before the line could be completed, and the coaches withdrawn which were supplying the link between the two lengths of

railway separated by this unfortunate tunnel.

Very similar trouble was experienced on the much greater venture under the Severn. This tunnel was not rendered necessary by any obstinate landowners, rather was it entered upon to improve the service of the Great Western to the coalfields and large towns of South Wales.

The Severn is easily the greatest of our English rivers, and it has a singularly wide estuary, involving, with its approaches, a tunnel under the water of no less than four and a half miles. Unfortunately for the engineers they found the Severn a singularly fickle river; it overflowed its banks at unexpected moments, it was subject to a bore (a tidal wave), and the bottom of the river was porous to an extent not guessed.

From the outset it was necessary to install pumps and in ordinary circumstances they were sufficient to deal with the inflow and also the flooding from high tides. But when the Great Spring, as it came to be called, was encountered there was consternation.

The men barely escaped with their lives, and the work of months was ruined in an hour or so. By great efforts the water was pumped out, and the Great Spring penned in so that it should do no further damage.

But now a worse disaster was brewing. There had been a succession of high tides which had worried the engineers, though they felt that all would be well so long as nothing worse supervened. There was one danger which the local people feared, and they warned the workers; it was that if a strong wind was blowing against the tide there would probably be trouble. At first the winds were kind, and then came an ominous change. The wind shifted and blew heavily downstream. The tide was flowing in strongly, far higher than was commonly experienced, and it met the wind.

Now came a struggle between wind and water and the former won, forcing back the water and causing it to spread above the low-lying banks of the Severn. This

inevitably meant the flooding of the land for miles around; worse still, it meant the flooding of the huts used by the tunnel workers. Six feet of water was no uncommon depth in these huts, and had the inhabitants not been warned they must have been drowned like rats in a trap. On went the irresistible flood and poured down the workings, again flooding them, and making the position worse than before. There were close upon a hundred men imprisoned in the workings; too late the warning reached them, and all they could do was to retreat further into the tunnel to reach a shaft.

Their position was truly terrible, for the water was still rising, and they were in total darkness. It seemed impossible that they should escape, and had the tide gone on rising they could not have been rescued. Fortunately, when the flooding occurred, the tide was on the ebb, and thus no further flooding took place; even so the work of rescue was no easy matter. Another fortunate circumstance was the fact that above

ground was a man in charge of singular energy and resourcefulness. He at once obtained a small boat, had it conveyed to the shaft, and then let down until it was afloat in the water of the tunnel. There was no lack of volunteers, and they rowed off into the workings, flares lighting up the hitherto sombreness of the tunnel. Alas, they had not proceeded far when progress was barred by a series of timber piles which had been driven in to support the roof.

They were, of course, near the roof in their boat, and here the piles from either side met and formed an impenetrable barrier. Beyond were the marooned men, and it was uncertain then whether the water was still rising. Back they rowed and obtained a saw with which to cut their way through the piles, risking the collapse of the roof by their removal.

When work was well in progress ill-luck again baulked the efforts of the rescuers, the saw was dropped overboard, and back they had to go again for

another. By real hard work they worked their way through, and when the imprisoned men had began to lose all hope of rescue the boat reached them, and a few at a time were carried to the shaft until every fellow had been safely landed.

It was necessary to employ divers to enter the workings and close certain valves. This again was a very hazardous undertaking, because the workings were cumbered with hastily dropped tools and floating timber.

Lambert, a diver who had many surprising and dangerous adventures in sunken ships, never had a more onerous task than this he undertook below the Severn. And, owing to a mistake in his instructions, he had to make a double trip, the second being undertaken with a new self-contained diving dress which enabled the air tube to be dispensed with.

Many years were spent in the construction of this magnificent tunnel, and when it was opened in 1887 it was agreed on all hands that no greater engineering feat had ever

been attempted in Britain. Huge pumping engines are constantly employed in keeping the tunnel free from water, but there has been no really serious trouble, and both expresses and goods trains are constantly passing through it.

The amount of water pumped up from the Severn tunnel each day would supply a fair-sized town with all its needs.

The task of boring such a tunnel as this would be much easier to-day owing to the increased use of electricity.

The Kilsby and the Severn are the greatest of the English tunnels, though the former is exceeded in length by several. But they are greatest in achievement and the conquering of obstacles which at one period seemed insurmountable.

To-day tunnelling is becoming more or less commonplace because we are so used to the successful cutting of tubes for London's underground railways. Here tunnelling has really been brought to a fine art by the employment of simple yet very effective

machinery. The Greathead Shield was an invention that followed quickly in action after the boring of the Severn Tunnel, and it provided a means of boring tunnels at depths which were formerly thought quite impracticable.

Simply described the Greathead Shield is a section of steel tube which can be lowered down a shaft. At the bottom the cutting machinery is set in action on the face of the proposed tunnel. As the cutters work their way forward the shield follows upon some temporary rails. The "spoil" is passed backwards to trucks which are already in position, and these run upon the temporary track to the bottom of the shaft where it is raised to the surface and disposed of.

As the shield goes forward the steel tube, surrounded by a concrete coating, is built into position ready for the laying of the permanent track. In practice a tube is bored from several shafts, and a shield is working in either direction from the foot of a single shaft.

The marvel of the engineering feat here is not so much the boring as the accuracy with which it is accomplished. When the sections meet there is rarely more than an inch out in the measurements!

V

BY ROAD AND RAIL

WITH the ever increasing invasion of the road by the fast motor-coach the railways get more and more alarmed for their traffic, and are therefore ready to consider anything which will help them in their desperate fight against the new-comer.

It has long been seen that a dual purpose vehicle would help the railways against the road, and within recent months the L.M.S. Railway has experimented with a new type of omnibus which will serve equally well on road or rail. This is the Karrier Ro-railer.

In previous attempts whatever was likely to be gained by a convertible vehicle was lost by the time taken up or method of transition from a rail to a road unit.

The Karrier Motors, of Huddersfield, have tried their utmost to meet the needs of the railway engaged in road work as well as in the running of trains. In the Ro-railer they appear to have succeeded. At first glance we have just an ordinary motor-coach, but the observant will quickly detect several significant features. First there are buffers at front and rear, and, secondly, there are some suspicious looking wheels tucked away within a few inches of the ordinary pneumatic-tyred wheels used for the road. The rail wheels are smaller, and, of course are flanged. They are locked to an eccentric which keeps them clear of the road when the vehicle is employed upon the highway. They are on the same axle which is prolonged to provide for the road wheels.

In the first test the Ro-railer set off upon a branch of the late Midland system and, travelling at the rate of 40 to 50 miles an hour, it ran both smoothly and well, actually attaining a higher rate of speed than is employed by the train which it is expected

to supplant. At the end of the line it ran into a siding where some sleepers had been so placed that they brought the ground level up to that of the rail top. In three minutes the road wheels were lowered and the rail wheels raised.

The Ro-railer then became to all intents and purposes a motor-coach and ran smoothly through the town, made a tour for exhibition purposes, returned to the siding again, was converted for rail travel and off it went—the whole transference having been accomplished in six minutes for both changes.

Those who made the journey remarked that at the same speed the travelling was better on the road than on the railway, a fact which is sufficiently remarkable until we remember that the line upon which the experiment was carried out was a branch, and therefore not so well laid as the main line. There was more swaying noticeable but then speed was higher on the whole, also the day was wet and sand had to be used on the slippery rails, the coach

being provided with this accessory in anticipation of such conditions obtaining at times.

Although the first Ro-railer put in service is a passenger vehicle it is hoped to provide goods units, and these will play a very important part in dealing with what may be called a self contained load. By this is meant a load from its point of origin for a single consignee. It will be possible for the Ro-railer to be sent to a factory, pick up its load, get back to the railway, and then run a distance without limit to the station of destination where it will become road borne again for delivery at the consignees.

Up to ten tons weight of goods could be dealt as with a single unit, and at a speed on the railway which would not be safe on the highway. An all night trip could be made between towns from 200 to 300 miles apart.

For the present the Ro-railer seems to have a special advantage for branch line passenger services, particularly where the

town or village is situated some distance from the terminus. It is frequent in Britain for the railway to miss a town or village by a couple of miles, possibly due to the foolish opposition of landowners when railways were in their infancy. That town or village has suffered ever since, and now the road coach or bus is trying to take its traffic from the railway. Here the latter has an ally in the new vehicle because it can serve all the intermediate places on the branch line then, where necessary leave the railway and rejoin it at a spot later on, having given a direct service to the villages and towns which lie off the rail route.

In addition, whilst travelling along the railway, the Ro-railer can stop and pick up passengers without undue delay or trouble.

When the vehicle is running on the road the rail wheels are also revolving; these latter are of the laminated wood wheel type familiar to most of us in another form upon the railway coach. Such wheels are

much less noisy when running on railways than the all-metal type.

When running on the rail the Ro-railer can be utilised for towing other vehicles and this should make it still more useful as a rail unit.

To enable passengers to alight and board the vehicle easily when at railway platforms a very ingenious sliding floor is employed; when picking up from the road there are two steps available.

In order, when the former system is in use that no damage shall result to the coach by it starting before the sliding floor is withdrawn by the guard, a warning light is shown in the cab. The engines are of the six cylinder type giving a horse-power of 65–110 (R.A.C. rating 37·2).

It has been proved that whilst the road resistance is 30 to 40 lb. per ton, that of the rail for the same vehicle is only 12 lb. per ton.

It should therefore be more profitable to run the Ro-railer on the railway, especially

as tests have proved that on the rail the petrol consumption is exactly half that on the road with the same loading. Unladen, the Ro-railer weighs 7 tons, 2½ cwt.

VI

FLOATING DOCKS

WITH recent years the largest floating dock in the world has been placed at Southampton. It will take not only the largest vessel now afloat—such monsters as the 56,000 tonners *Majestic* and *Leviathan*, but it is large enough for even bigger ships should they be built.

The most common type is that which is shaped like a large oblong box, without end and with hollow sides and bottom. Normally it is floating well above water, but when required for use the air chambers are flooded until it sinks down anything from 20 to 35 feet, according to the draught of the ship which is about to be warped in. So soon as its burden is safely inside, and in proper position, powerful pumps begin to empty the water from the air-chambers,

and in a couple of hours, or even less, the ship within is high and dry, ready for overhaul or repair. As every ship must be dry-docked at least annually, you can imagine that a floating dock is kept well employed.

The demands made upon it set an inventor to work, and he produced a plan by which a single dock could lift several ships a day clear from their element, but it was necessary to have somewhere for them to be deposited. This is the depositing dock, and it works in connection with what are called grids.

Imagine several steel sections, shaped like the letter " L," placed in series at the river side, with a little space left between each of the sections. A dozen or more sections make one grid. The sections of a grid are all connected, and are held in position at the back. The floating dock itself is an opposite series of sections, like the letter " L " reversed, thus—⅃. This type of floating dock has no ends, nor has it a left-hand side. The ship is warped on to the

submerged fingers of the dock, and is then raised by pumping out. The dock, with its burden, is then towed alongside one of the series of grids. By careful handling the depositing dock has its fingers inserted between those of the fixed section. Then the water is again admitted to the air-chambers, the depositing dock sinks, leaving the ship on the grid. The depositing dock is then drawn away from the grid, and work is commenced on the ship.

VII

SOME TUNNELLING FEATS

WHAT would Napoleon have given for a tunnel under the Alps and the trains, which convey, without effort, thousands of people in a fraction of the time it took to get those troops over one section of the great mountain passes!

These great feats of engineering dwarf completely anything in this country, but it is only fair to our own engineers to state that from the point of view of danger and drawbacks, the tunnel under the Severn vies with anything attempted abroad.

The Alps are pierced by several great tunnels to-day, yet who, off-hand, could mention the name of one of the engineers who were responsible for them?

It is one of the ironies of life that the men who have been constructive in their

lives are forgotten, whilst those who were the opposite are remembered, and even receive the affix " Great " to their names—Napoleon for example.

Before any of these magnificent tunnels were started upon which pierce the Alps, and give direct rail connection between France, Germany, Switzerland with Italy, and other countries lying south of these ranges, a tremendous amount of careful surveying had to be undertaken.

To the average person it seems quite impossible that a long tunnel through mountain ranges can be started from both ends and then meet within a fraction of a foot within the heart of a great peak. How can the engineer, without actually walking over the peak—a feat often quite impossible—be sure that his two tunnels will meet and not miss each other by yards, if not by miles?

He would answer, " By careful calculations made with compass and theodolite and checked over and over again to ensure their correctness." Even so it seems some-

thing of a miracle, and if we give it a thought we shall see here one of the greatest achievements in theory carried safely forward into practice.

Years were given to the surveys of these Alpine tunnels, and until they were satisfactory there could be no question of awarding the contract.

It is not generally known that the tunnel engineer usually contrives his mountain boring upon an incline, which will not be too great a strain upon the locomotive. Thus there is a point—usually half-way—where there is a summit. It is shown very clearly where this summit is placed by the laboured breathing of the locomotive becoming easier, and then by a perceptible increase in speed as the train starts upon its descent. The extra fuel needed for the ascent is compensated very frequently by the possibility of cutting off steam completely for some miles upon the descent.

In the case of the Alpine tunnels, however, electric locomotives have either ousted already, or are threatening to oust, the

hard-working steam locomotive. The main reason for this inclined tunnelling is to drain away quickly any springs or percolating water. If the easier task of cutting the tunnel upon a perfectly level gradient were pursued there would be constant trouble encountered from water, both during boring and after completion.

Although water may be the worst enemy there are several others, not the least being a proper ventilation system. Important for the finished tunnel, it is even more so during construction otherwise the workers would be overcome, or, at the best, their working hours at the face of the excavation would be seriously cut into.

Another uncertainty is the nature of the strata through which the tunnel is driven. This is impossible to determine in the case of mountain tunnels, and endless trouble is occasioned through this uncertainty.

In the early days of railways, particularly abroad, the engineers responsible would gladly take a circuitous route rather than bore through a mountain range. The

advance of the art of tunnelling is so great that in very many instances the roundabout route has now been abandoned in favour of a direct tunnel under the mountains.

The first of the Alpine tunnels was that known as the Mont Cenis. This was driven by Italian engineers through the Grand Vallon, to link up the Paris–Marseilles railway with those serving Turin, a branch line being also constructed to complete the link.

The first blast was fired in the construction of this tunnel in 1857, and four years later the machine drill was introduced. This led to considerable speeding up; even so, it took another ten years before the trains could pass from France to Italy without hindrance. The length is less than eight miles. How greatly the air drill helped the engineer may be gathered, when it is stated that during the first four years, when all work was done by hand, the progress was only at the rate of 9 inches a day upon either side of the Alps. When the compressed air drill was fairly at work 45 inches a day were driven through the granite.

A year after opening of the Mont Cenis tunnel a new one under Mont St. Gotthard was started to link up Belgium, Germany and Switzerland with Italy. This has a length of slightly more than nine miles, but the greatest achievement of the engineers was undoubtedly the building of several spiral approaches with which to gain altitude. Thus the train doubles on its course, so that there are places where the locomotive and its train is running many feet above where it was climbing a few minutes earlier. The great advantage of the air drill was demonstrated more clearly in the St. Gotthard tunnel, the work being accomplished in nine years.

Next came the Arlberg tunnel which was begun in 1880, and so great was the progress made that it was completed in a little over three years. The rate of progress was close upon 30 feet a day, and by careful organisation the work of bricking the tunnel was carried forward at the same rate as it was excavated. It will be clear that the farther the boring is driven into the moun-

tain the greater are the difficulties encountered in removing the spoil and bringing along the bricks and cement. In the Arlberg tunnel 900 tons of spoil and 350 tons of masonry had to be moved each day from or to either face.

The Simplon tunnel was next undertaken; this was begun in 1898, and completed seven years later. This is rather more than 12 miles long, and it was constructed upon an entirely new plan. Two parallel headings were driven through the mountain, and then, at agreed upon points, cross-headings were driven to connect the two tunnels. These served to ventilate the headings, and then one of them was enlarged to allow of the track being laid, but the other was left in its original condition for thirteen years when it was undertaken and completed soon after the Great War. During the cutting of this double tunnel both cold and hot springs were encountered.

A name which is inseparably connected with the Simplon tunnel is that of Alfred Brandt, who not only provided the improved

A Small Provincial Telephone Exchange

[*Face page* 64

A Recent Design of Telephone Call-Box

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drills used in the work but gave his best energies to seeing it pushed forward. He was a victim to his profession, being killed by a fall of rock. Next came the Loetschberg, a fraction over 9 miles in length. As originally planned, the tunnel was to have been perfectly straight and 8½ miles in length. A serious disaster threatened to end the project. After driving the heading 2 miles through granite the men suddenly broke into an ancient glacial gorge with an underground river in its bed. In a few moments the men and their equipment were overwhelmed and lost beyond recovery. Twenty-five men perished. Not to be beaten the engineers blocked up the gap, turned the course of the tunnel, and found the solid granite once more.

Coming to the New World we note the wonderful achievement of piercing the Andes. In point of length the tunnel is insignificant, but in point of merit it is one of the most splendid achievements of the engineer. The railway itself is a masterpiece of careful planning on either side of

the Andes. On the eastern side, in Argentina, the ascent is fairly gradual, although towards the end there are some stiff gradients laid down upon the rack-rail principle, but on the Chilean side of the Andes there is a sheer drop of something like 3,150 feet, whilst in 46 miles to the coast there is a difference in levels of 8,000 feet.

The tunnel was cut through the last two miles of the mountains and the traveller may be impressed to think that he is proceeding at a depth of 2,630 feet below the old mountain road.

Over 2,000 men were employed on the two-mile tunnel cut through some of the hardest rock that drills have ever tackled; indeed, the first drills would make no impression and time was lost whilst a fresh battery was obtained. Then, with the aid of dynamite, the work went on steadily, the men being divided into eight-hour shifts so that the boring was continuous. It was most trying work for these poor fellows. Two miles above sea level meant rarefied air, and it was bitterly cold. Yet

when they entered the heading, and got into the heart of the mountain the heat was extremely trying. What with these alternating spells of intense cold and great heat the death-roll was rather heavy, and sickness made constant vacancies in the gangs.

As usual, the tunnel was driven from either side, and there came a day when the engineers broke through and clasped hands.

VIII

THE EVOLUTION OF THE TELEPHONES

No one knows exactly who invented the telephone; there are quite a number of claimants to that honour. But to Graham Bell must greatest credit be given amongst the early pioneers, because he solved many problems which had baffled previous experimenters. Just a little more than fifty years ago Graham Bell succeeded in reproducing sounds at a distance by means of electricity.

And from that first successful trial in America we have the wonderful and complex system of to-day, amongst which the British is one of the best. Sometimes you will see in the Press that it is the worst—the writer has had a bad telephone day, so like the fisherman who has had no catch, he condemns the whole system.

" How does the telephone work? " is a question that must often have been asked of father. And father, having had a busy day, in which, perhaps, his telephone has annoyed rather than helped, will not give a satisfying answer. Well, of course, like all electrical gadgets it *is* a little intricate, and you would not thank me to go too deeply into details. Here is something of what takes place when a call is required.

There are three distinct parts of the telephone which you and I know—these are fairly simple. In the Exchange there are thousands of parts, which would take a whole book to explain. The three parts that matter at the moment, are the transmitter, the line wires, and the receiver—items one and three are similar. The receiver (and transmitter) consists of a horseshoe magnet, fitted with a small extension piece of soft iron at each end. The magnet is placed very near to the centre of a disc of thin sheet iron, the centre of which is inclined slightly towards the poles of the magnet. Round each pole of the

magnet is a bobbin of very fine wire, the ends of which are joined to the ends of the two line wires. If you look at the next telephone line you pass you will notice that there are generally two lines for each service, and that they cross each other on their journey from pole to pole to obviate what is called induction.

When the telephone is used the sound of the voice enters the transmitter, the sound waves strike upon the disc, and so causes it to vibrate, and the vibrations follow exactly the sound waves. These are carried along by means of the magnetic current, flow along the line, and are then reproduced on the microphone.

Those are the general principles of the working of the transmitter, line and receiver. Now we can get outside again for a moment and look at the lines. These are of copper, though there were many steel lines in existence. Though galvanised, steel wires quickly rust, and there is a loss of effectiveness. Now, as far as possible, the trunk routes (and also City lines) are being put

underground in cables. Overhead lines suffer in storms, and communication is often broken down from this cause. But even the cables are not free from trouble—water is the greatest enemy, and if the slightest crack develops in the covering material, water will penetrate and interfere seriously with transmission. Quite recently a large exchange was cut off from London entirely through storm water penetrating the cable ducts.

A cable will contain hundreds of wires, in pairs, and in order that they may be identified more readily, each wire has its wrapping of coloured paper, the colours arranged in sequence. The wires are then covered with a waterproof insulating material, and finally they are armoured with a lead jacket. Earthenware pipes are laid, these are called ducts, and through them the long cables are pulled.

Now come to the telephone exchange—the place with a thousand eyes which glare at the stranger entering the large room of mystery. Most of the eyes are white—or

rather opal, but some appear bloodshot, these latter indicate a public service such as a call office. Each wire from the cables or from the overhead lines is led into the exchange, and here it ends at the back of the switchboard. Connected to each wire is an indicator which signals the operator when the person at the other end of the line desires to make a call. One thing in particular strikes us in the exchange—that is the absence of bells. At our end we get the thrilling sound of the telephone bell too often, and we talk glibly of ringing up the exchange. If we did, those poor girls would be driven to sheer desperation; it is quite bad enough to have a succession of eyes winking at one. When we need to make a connection, we lift our receiver from its usual position, and straightway in the distant exchange an opal eye becomes bright, a minute electric bulb being ignited by the lifting of the receiver.

The actual termination of the caller's wire is termed a jack, and several hundreds of them will confront the telephonist. She

is not expected to attend to all the callers they represent, and all the numbers which she has on her board will be duplicated on others.

Immediately one of the eyes flashes its message, the telephonist plugs into the jack, and asks for the number required. If the number should be on the same exchange, i.e. a local one, the connection is made at once, but should it be for a long-distance call, then several connections will have to be made.

The telephonist enters the service as a young girl, often as a girl probationer. These have indoor work something like that given to juniors in a commercial office; collecting duties and so on. Then she passes to the telephone school, though a few are selected to be trained in telegraphy. As more telephonists are usually required than there are girl probationers, there is also the direct entry into the class from the ages of 16 to 19. The training is a very careful one, and any girl who cannot adapt herself to the work must seek employment

elsewhere. There is a medical examination to pass, besides the training, and a Civil Service certificate must be obtained before a new-comer can be appointed to an established position. The examination is not very difficult, and any girl who has reached the highest standard in an elementary school should have no difficulty in getting through.

The training in the school is very interesting, the telephone ear and the telephone voice receiving special attention. The voice must be distinct, low, and penetrating. The "r's" must be rolled, and there are certain figures which must be pronounced in a way entirely different from that usually used. This is very necessary, or the wrong caller would constantly be summoned.

The low speech of the telephonist is at once noticeable on visiting an exchange; instead of a babel of voices one hears just a subdued murmur, far different from that of the irate gentleman who brings down the house when he speaks telephonically. It is, of course, very necessary that the telephonist should hear a low voice, besides possessing

one. She must, therefore, acquire the telephone ear. What that acquisition amounts to may perhaps be best shown by thinking of wireless and the crystal set. A practised telephonist would have no real difficulty in listening to what was being broadcast, even if there was considerable noise in the room, but the average person makes frantic appeals to all to be quiet so that he or she may catch an important item of news.

The telephone ear is cultivated in the training school by the novice wearing a head-piece which allows one ear freedom, whilst the other is placed at the receiver. At the beginning of her training the newcomer rarely hears a sound via the receiver, though someone is speaking to her from a very short distance, but, within a week, she becomes oblivious to outside noises, and hears only through the receiver.

The career of a telephonist has several very definite advantages, but hard work is the keynote of her calling. She may rise to be a supervisor; she has a pension at the

end of her service, or a gratuity if she should leave to get married. There are other advantages which are common to Government servants, and the fact that the position is a permanent one weighs with candidates for what has been called " The Hello Service." By the way, a telephonist must never say " Hullo ".

In one corner of the exchange is a set of numbers, and if one watches them closely for a moment a click is heard and then something like the working of a cyclometer, another mile is added to the total, the mile being a call in this case. Before these meters were introduced the telephonist had to record each call upon a little ticket, and there was an enormous amount of work involved in sorting out the slips of paper, and then making out the quarterly bill for calls. A touch by the telephonist works the register meter. The meters are for local calls; tickets must be made for what are called " trunk " services.

Girls staff the exchanges by day, usually from 8 a.m. till 8 p.m., then men come on

for the night hours, though such an arrangement does not apply to all exchanges, especially where the night work is comparatively light.

Not so long ago a newspaper announced that the telephonist would be extinct in a few years owing to the rapid extension of the automatic telephone exchanges. The journalist was quite wrong. It is more than possible that, when the whole country is linked by automatic working, the actual number of telephonists will be much the same as now. The automatic exchange largely eliminates the local telephonist, but the trunk operator will remain. As the telephone habit is growing rapidly, and with it the number of lines and calls, the loss of staff due to the automatic working will be offset by the greater number of trunk calls required. Once the householder has the telephone installed he is not content to use his 'phone for purely local calls; he will want to talk with distant friends, so the telephonist is not likely to become a back number, especially as the automatic

is not feasible, at the moment, for more than local working.

The day may come when everybody will be their own operator, using wireless telephony for communication. It is, of course, a dream, but, in this age of wonders, so many dreams have come true that it is never safe to say: "That is quite impossible."

The automatic telephone and its working is too complex for description here. But here is something of the simpler side of automatic working. The usual telephone receiver is fitted with a dial with numbers 1 to 0. All the numbers on the automatic exchange must consist of a group of four figures, that is why, at the moment, in anticipation of the change-over to automatic working, the numbers in the London area are being altered to four figures. When a call is wanted, the receiver is lifted off its hook in the usual way, and if a low hum is heard, then you know that you have your connection with the exchange. The dial is then operated by placing a finger in the

number hole corresponding to the group of four figures, which comprises the telephone number of the subscriber whom it is desired to engage. Then you bring each of the four numbers round in turn to the stop position, and then release quickly each time a number is recorded upon the line. If the call is effective, you hear the ring of a bell; if not, you hear a steady droning noise showing that your subscriber is engaged.

In the silent exchange there are tiers of switches, and here, by very complicated and delicate electric instruments, the connections are made good. I should want several pages to describe exactly what happens here, so we will push on to note what is perhaps the greatest and most recent development in telephony—this is telephone conversation with America and the Dominions. Our Post Office experts have been working on the problem for a very long time, and now success has crowned their efforts. How far-reaching such services may prove, it is yet too early to say.

For some years telephony to France has been a regular feature of the service, and quite recently all parts of Germany have been linked with this country by submarine and underground cables. Holland and Belgium were already in connection, so the day is not far distant when all European countries will be able to speak with Britain; this, of course, quite apart from wireless.

By courtesy of "The Motor Boat"

RACING MOTOR-BOATS AT FULL SPEED

[*Face page* 80

[By courtesy of "The Motor Boat"

ONE OF THE LATEST TYPES OF SPEED BOAT

Face page 81]

IX

THE SPEED BOAT

It does not seem so very long ago that the tiny *Turbinia* made her historic dash between the lines of warships at Spithead and proclaimed to the world that a new factor in speed had been developed. She was the first turbine-driven vessel, built to demonstrate the superiority of the turbine over the old-fashioned reciprocating machinery. The story is still told of a couple of destroyers ordered to chase the truant and head her off, demanding at the same time an explanation for her intrusion. The fastest destroyers in the world were unable to catch up with that cheeky little craft and thus they retired, beaten for the first time, and by a stranger.

From the *Turbinia* came the fleet warship and also the fast liner, culminating in

such craft as the *Mauretania* and the *Bremen.* Either of these are much slower than the latest destroyers, but again the fastest warship travels at less than half the pace of the speed boat such as *Miss England II.* She is indeed a wonderful craft, and interest in her will never die, mainly because of the sad event, the loss of Sir Henry Seagrave, during her successful attempt on the speed record. Since her misadventure and loss she has been doing splendid trips under Mr. Kaye Don.

Here are a few facts about this superb speed boat. In the first place her engines develop 4,000 horse-power, yet her propeller is quite a tiny affair, but it turns at 12,000 revolutions a minute! The stem of the boat is of stainless steel, and its edge is like a razor.

X

THE RIVER TRAINS

A Belgian engineer has perfected a most ingenious system of transport for use on the river Congo and its tributaries. Difficulties of transport have always been a drawback to the development of the Belgian Congo, and many efforts have been made in the past to improve upon existing methods. Now comes the river train, a system of mechanical portage designed to solve the problem of river transport where rapids are a bar to transport of the usual type. The power unit for the river train is a 300 horse-power steam launch of an unusual type. The train consists of a series of twin-hulled boats, 90 feet long, six to eight being employed with each train.

In order to appreciate fully what exactly is in the mind of the inventor we have to

realise that the vast Belgian Congo is splendidly supplied with a river system which is unexcelled in any similar area. Not only is there the Congo River, but there are numerous tributaries which make up something like 11,000 miles of inland waterways within the colony.

Unfortunately, apart from rapids, a great deal of this total is made up of stretches of water which has an insufficient depth for the steamboat or barge of the usual type. Indeed, a recent series of careful surveys shows that there are about 9,000 miles of waterways where a craft must have a draught of not more than three feet; another 1,800 miles will take boats drawing up to six feet, whilst the remainder—about 600 miles in all—is available for ocean-going craft.

Something has been attempted—and successfully so far as the experiments have been carried out—with aircraft, particularly of the seaplane and flying-boat types, but it will be appreciated at once that the load of such craft is negligible in comparison

with barges. As the exports of the Belgian Congo are for the most part of a heavy nature, it is clear that aircraft whilst useful for fast and light traffic, and particularly for passengers, cannot take the place of river transport—hence the river train.

Up to its coming the mode of transport was slow and costly, consisting of light draught canoes with hand portage wherever the rapids were encountered, or again where shallows made navigation impracticable.

The amount of trans-shipment rendered necessary from such a course was tremendous, and the exports and imports to the Belgian Congo suffered considerably in handling.

The double-hulled barges comprising the river train take to land wherever the river is impracticable, becoming, for the time being, a mono-rail train. Assume for a moment that the barges are in tow of the tug and making good progress upstream. There are rapids ahead which will check the progress of the river train. But at the

side of the stream, just before the rapids are reached, a cutting into the bank is observed to which the tug is headed. So soon as the tug and its burden are within the channel it is observed that it takes a curve to bring it parallel with the river, though it left it at right angles.

Along the centre of this channel piles have been sunk, and care has been taken to ensure that whatever the state of the stream, there shall always be sufficient water to cover the piles. As the channel goes on the piles come nearer and nearer the surface. Upon the piles, towards the end of the channel, a mono-rail is laid and the wheels which are placed within the saddle of the double hull engage upon the rail so soon as the river train is drawn sufficiently on to the slight upward slope of the piles.

The piles go on to dry land and the mono-rail is laid across them until a similar channel is encountered beyond the rapids, where the river train takes to the water again by reversing the process just described.

The piles are of no ordinary type, for they are called upon to take a load, estimated at 80 tons per pile. There must be no movement nor subsidence, and they are therefore sunk in solid concrete to a considerable depth.

At first it was thought that some stationary or motive power on the land would have to do the work of taking the river train round the loop which circumvented the rapids, but the inventor came to the conclusion that this method was not only unnecessary, but would largely destroy the economic working which was his prime objective.

He, therefore, planned the tug on the double-hulled system also and divided his power unit in two. Thus, there is a 150 horse-power engine in each section of the hull. Each engine drives its own screw when the boat is water-borne, and when it begins its climb out of the water to negotiate the land loop, the screw is disconnected and the power of the engine transmitted to the wheels by means of coupled transmission

gear, quite a simple operation and one which has been proved to be efficient.

It is a wonderful achievement really to have produced a tug which is equally at home on land or water, and it is remarkable to see her leave the water, ascend gradually the inclined mono-rail, travel along the level for a short distance, and then head for the second channel with her train of barges behind her. In order that these shall not over-run their mentor on the descent to the water again, a set of powerful shoe brakes is supplied for the wheels. These, by the way, consist of four sets of two wheels in line.

The two hulls are quite distinct as units, and are steel-built. They are joined by a platform, under which are the wheels referred to. The platform is laid upon transverse girders, and it serves as a connecting link between the train and also as the bridge of the craft. The total beam of the double-hulled barge is 18 feet, and when rail-borne they maintain their equilibrium,

which is truly remarkable all things considered.

The brakes on the wheels are controlled by the helmsman who stands on the gangway.

In order that no delay shall be sustained when water-borne the screws of the tug are housed in deep recesses, and this plan not only keeps them free from weed and other obstructions in the river, but allows them to function properly in very shallow water. The rudders are of the twin type, coupled together with light steel cables, and the system gives great controllability, which is very desirable in towing.

Bumpers are fitted across the sterns, and there is some protection given at the stem in case of contact with another unit or some obstruction.

Whilst water-borne it is found desirable to employ tow ropes, but when the loop channel is reached, and before the tug commences her ascent of the gradient, the tow ropes are replaced by short, flexible couplings.

It may be wondered how the barges are got upon the mono-rail. This is really an automatic procedure due to the gradual narrowing of the channel, which forces the barges into a confined space at the centre in which are the piles and their superimposed rail.

Each barge has a helmsman afloat, and he becomes the brakesman ashore. The change over from screw drive to wheel propulsion is accomplished as soon as the tug is astride of the rail and whilst the propellers are still submerged; this prevents the screws racing with possible damage to their shafts.

The change over from water to rail takes less than ten minutes, and although the speed on the rail is less than in the water, a rate of five miles an hour was maintained when the trials were carried out on the canal at Willebroeck just outside Antwerp.

The operation of the river train will be watched very carefully by those who are faced with similar transport conditions, but it needs little consideration to arrive at the

point that the idea has great possibilities, and that it would be cheaper to introduce the river train on waters which have not been canalised rather than to attempt the latter.

XI

SPEED AND THE ENGINEER

WHAT is the most remarkable revolution accomplished in the last century? If just a little thought is given to the subject the answer would surely be "The revolution in speed."

Rather more than a century ago the directors of the Liverpool and Manchester railway, with considerable trepidation, were formulating the conditions for a trial of locomotives. A commission had reported against their use, suggesting the rope and stationary engine at various points along the thirty miles of track.

Many of the directors favoured the use of horses for haulage, and George Stephenson had the greatest difficulty in persuading his employers to let the locomotive have a look in at all.

One of the conditions make us smile to-day, it was that the engine should attain 10 miles an hour with a load of 30 tons!

Ten miles an hour—that represented the triumph of speed a century ago!

The speed limit for the locomotive was arrived at quite simply—the best speed of the road coach was taken and the steam locomotive was expected to reach it. There were some brave souls who hoped that the infant locomotive would manage to keep his boiler intact and yet go a little faster than 10 miles. One director, at least, raised the hair of his colleagues by saying that he looked confidently forward to the day when the journey of 30 miles between the two terminals of the Liverpool and Manchester would be run in an hour. " God forbid," said another. " That would indeed be flying in the face of Providence. Don't you see, man, that it represents three times the speed of the road coach? " And so they left it for a time.

At the Rainhill trials, whose centenary passed in October 1929, the " Rocket "

was the only engine of those entered to fulfil the conditions, passing the ten-mile test and actually averaging something like 15 miles an hour for the whole of her trips, whilst at a special trial she reached 35 miles an hour. The triumph of speed indeed!

Now there are two kinds of speed—the spectacular and the useful, and in the instances we are to consider let us keep those two kinds always in mind. Some prefer spectacular—most young folk do—others will prefer the useful—a speed which may serve every day and without any special preparation. Thus, talking still of the iron road, let us see the two kinds of speed upon it, tracing very briefly the upward tendency upon the railway.

Speeds rose rapidly as soon as the railways settled down to work; very soon the average rate of travel of the express train had reached 30 miles an hour. This appears slow to us, but one must consider it as relative to the best on the road and here then we have a 300 per cent increase in,

say twenty years. Then it went ahead, but, strange as it may seem, the average speed of the best express work accomplished in Britain to-day is less than 50 miles an hour. That does not look like the triumph of speed does it? But think again of the loads carried at the rate and here we have the useful speed. Six hundred tons by a single locomotive at close upon fifty miles an hour for three hundred miles on end, well—that is really a singularly wonderful triumph and there is nothing so good if load be considered on sea, on road or in the air. Such a speed as the "Flying Scotsman" gives, for instance, is far below what the locomotive could perform, even so to average 47 miles an hour means frequent stretches at over sixty and often that gallant green-coated steed, with a load which would have shocked our forebears, attains eighty miles an hour.

The finest recorded speed of a train—this as apart from an unattached locomotive—was accomplished on the Great Western in May, 1904, when a 4–4–0 "City of

Truro" was clocked at 102.3 miles an hour between Exeter and Bristol. Higher speeds are frequently quoted, but in no case will they bear the criticism which may be applied, i.e. "By how many independent travellers was the alleged speed recorded?" In the case of the "City of Truro", with her mail train, there were several experienced checkers on board, who each made their notes of passing times, each with a specially tested stop-watch, and they all agreed within a fraction of a mile.

There we have the triumph of speed, but I would not call the 102.3 miles an hour the triumph of *useful* speed, because special preparation was given and it was necessary to have the course quite clear for the light mail special. On the other hand it is almost certain that when the railways settle down fairly, after their grouping experiences and the general standard of track improvement is further advanced, the average speed of our expresses will be raised from its present figure to at least 60 miles an hour between terminals. It will have to be so or the

R.M.S. "MAURETANIA"
For Many Years the Fastest Ship Afloat

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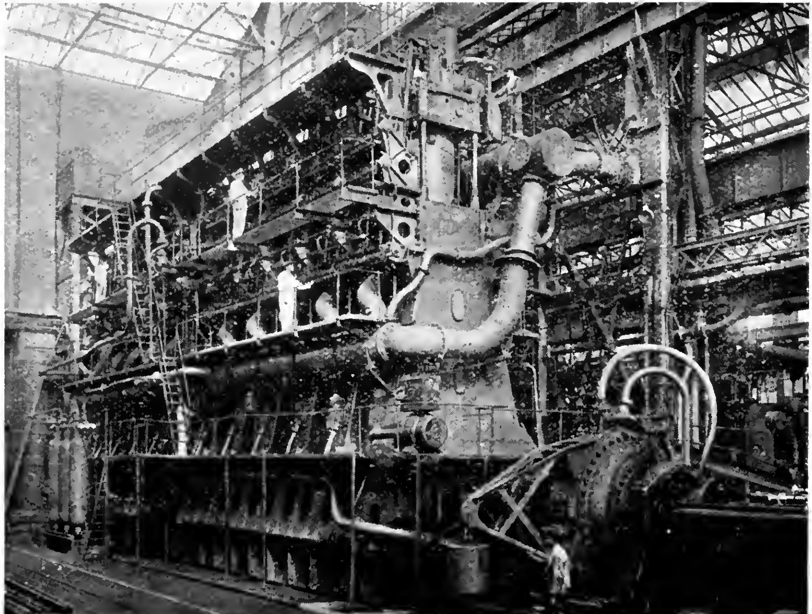

[*By courtesy of Harland & Wolff*

THE ENGINES OF M.V. "BRITANNIC"

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road coaches will take the express traffic as they have largely already filched the local.

Go back again a century for our comparison with the present speed on the ocean. Under sail high speeds were frequently registered when the wind served. Possibly the best speed would equal fifteen land miles an hour in the most favourable circumstances of wind and well-handled ships. But we get a finer appreciation of what steam has meant on the ocean when we note that a fast passenger sailing ship from Liverpool to New York took a round month, occasionally it was run under that time, but this involved weather conditions which were ideal, and, therefore, rarely met with on the North Atlantic.

A century ago the fast clippers had yet to appear on the scene, have their heyday and then disappear before the onward march of steam. The clipper represented the triumph of speed in sail, and we might say that the best was an equivalent of twenty miles an hour.

Steam came first to the river, and here the early paddlers were hopelessly outclassed by the fast sailers; indeed, on American waters in the early days of steam the skippers of the sailing craft would return their passengers' fares if they did not arrive well ahead of the steam-boat.

A hundred years ago the Atlantic had been crossed with ships having steam, not yet could they be called steamers, as they used their engines much in the same way as a sailing boat to-day would use her auxiliary power in the shape of a small motor engine.

It was in 1838 that the *Sirius*—a tiny cross-channel steamer—opened up the Atlantic Ferry under steam. Her speed was only that of a sailing ship—but—she was able to maintain it all the way across. Call it ten miles an hour all the way and we are not far out. So soon as the Cunarders had opened up their glorious record of safe and speedy travel on the ocean—that was in 1840—speed began to mount. The first Cunarder did very little better than the

Sirius and *Great Western*, the two first steam-driven ships on the famous ferry.

But as each ship came into service—and ten were built in as many years—an increase in speed was noticeable. From a fortnight taken in crossing, the time came down a day at a time usually, though sometimes merely a matter of an hour or two—until rather more than forty years after the opening of the steam service the crossing was accomplished in less than a week. This represented an increase of 100 per cent speed. There were many who believed that nothing more would be done, for the increase of a mile an hour on a liner means an enormous addition to the coal bill and a great deal to the cost of the ship.

There came a point when speed on the Atlantic seemed to halt because there was the question of a vessel earning her keep, also there were people who said that high speed was dangerous. They certainly could quote cases where liners had lost their propellers when racing at speed, and in

their going, besides rendering the ship helpless, much damage was done and twice at least a fine ship endangered.

But speed was demanded and again came the triumph of speed until we reach, by gradual but definite stages, the splendid *Mauretania* in 1907. For more than twenty years she remained supreme amongst liners, but then came the German ships *Bremen* and *Europa* and beat the old Cunarder. Even so she notched over 29 knots, more than 30 miles an hour, when extended.

Warships have already surpassed the *Mauretania* and the forty mile an hour has been well passed.

But speed on the water belongs not to steam, but to the petrol engine. Here we have again the break between useful and spectacular speed, between a great ship with huge earning power and the splendid, but not profitable, motor boats like *Miss America* and *Miss England*, the late Sir Henry Segrave's wonderful craft which easily beat all records in the spring of 1929 and 1930.

It seems hardly worth while recording the speeds attained by such craft as *Miss England*, by aircraft or by the racing motor car.

To write confidently of the record to-day means that before the printer can get to the setting up of his type a higher figure has been reached, one alters it in the proof and again before the printer can make the correction the record is obsolete.

And so it goes on—always the triumph of speed. There is no apparent limit and too often has the prophet been hopelessly out of it in these matters.

XII

THE MARVELLOUS TELEPRINTER

Boy Scouts and Girl Guides will know the Morse key upon which messages may be tapped out. For sixty years or so it has been the principal method of sending telegrams in the Post Office, now it is doomed. Something better has come along—the teleprinter. To look at, the teleprinter is exactly like a typewriter, indeed, it is a typewriter—but something more, because the message typed upon its keys is coming out in typewritten characters, perhaps 300 miles away.

The old Morse sounder, which has been the standard instrument for most telegraph offices, is capable of a speed of about 30 words a minute; the teleprinter can manage 60.

Although with the Morse sounder only one operator can use a key at a time, it is nevertheless quite simple for two messages to be sent in both directions on the same wire. One would think that the four telegrams being transmitted would become jumbled, and that a terrible mix-up would result. We may consider the wire, for the moment, like a wireless set upon which, by various wave lengths many stations may be secured. But here is a difference; with wireless only one station can be had at a time. With the telegraph instrument there are four messages travelling at the same time. We may, however, take the idea of wave lengths of varying strengths as showing what happens in the wire.

Unless the wire could be split, as it were, for the Teleprinter, it would not prove more economical than the Morse sounder. Actually the same method may obtain.

In the future, a telegraphist will have to be a typist, and touch-typing will be essential.

XIII

THE WELLAND CANAL

In September of 1930 Canada brought another great undertaking to a satisfactory conclusion; this was the Welland Canal connecting Lake Erie with the St. Lawrence waterway.

The Welland is rather different from what we understand by the word canal in Britain, since the largest liners at present running to Canada—that is vessels of 20,000 tons, could use its waters. No less than £24,000,000 were expended in cutting this great waterway, and it is a tribute to the farsightedness of the Canadian Government that they have undertaken this and similar schemes for linking the great rivers and lakes with the sea. Such undertakings have an important bearing on British commerce generally because eventually it will

enable the wheat of the greater part of the Dominion to be brought from the middle belt without transhipment.

In all, the Canadian ship canals comprise six distinct systems and their total mileage is close upon 1,600.

The new Welland Canal is an extension of a century-old canal which extended from Port Dalhousie on Lake Ontario to Port Robinson, where a connection was given with the Welland River. Although the original canal was only 27 miles long, it had to be given no less than 40 wooden locks to surmount the big difference in the level between its beginning and its end. Such a canal could scarcely be satisfactory, and within a few years various alterations were made in an endeavour to improve it.

The extensions carried out at the same time gave connections with Port Colborne on Lake Erie. As traffic grew the locks became congested, and a bold scheme was undertaken within ten years of the opening which had the effect of reducing the forty

locks to twenty-seven. Masonry took the place of wood and a considerable deepening took place to allow of the rapidly growing steam-boat traffic between the lakes and the river to be accommodated.

Even then the projectors did not foresee that remarkable grain trade which was to furnish the canal with the greater part of its traffic, whilst at the same time making for extreme congestion. One bold attempt to relieve this congestion was the designing of a special type of grain carrier—a vessel about 600 feet long, accommodating far more than the earlier types and making for economy of working. In practice it was still found that transhipment had to take place in the case of cargoes for Britain. It became obvious that the locks must be greatly enlarged, the canal deepened, and, if practicable, that the locks should be further reduced in number.

On careful consideration by the experts it seemed better to straighten out the route, indeed, to construct an entirely new length of 12 miles from Lake Ontario to Allanburg,

then onwards to Lake Erie by practically the same course as the old canal. By this scheme the locks have been reduced to eight and the length of the canal to 25 miles. These new locks are of a minimum length of 800 feet, 80 in width, and a depth of 30 feet on the sill.

The greatest of these locks has a length of 1,380 feet and has no rival in the whole world.

With the opening of the Welland Canal ships drawing 24 feet of water can voyage from the grain ports on Lake Superior to Prescott, Ontario, without discharging their cargo, thus allowing Canada to compete with other grain routes more favourably placed. At one time the larger vessels could not get beyond the Detroit river, but as Prescott stands at the head of the St. Lawrence rapids, Montreal is brought within about 120 miles.

To realise the huge distances of the inland waterways of Canada it is worth noting that there is uninterrupted navigation possible from the head of Lake Superior to

the Straits of Belle Isle—a distance of something like 2,384 miles.

There is a difference of 326½ feet in the levels of the Welland Canal, so it will be appreciated how wonderfully those immense locks serve.

XIV

THE RAILPLANE

EVER since railways were introduced the engineer has always been puzzling himself as to whether it would not be possible to do away with one of the two rails. Many systems have been tried, and although a fair measure of success has been attained, nothing has so far been evolved which is better than the present system of the dual rail.

The mono-rail has had a great deal of attention given to it, but it has not ever gone beyond the experimental stage, save perhaps in the case of the Laritgue system, which was employed in Ireland between Listowel and Ballybunion. This little system ran for many years, and although it had the element of success in it, there were so many disadvantages in

practice that it was not thought worth while continuing.

The latest attempt at a mono-rail system is known as the Bennie Railplane. An experimental installation has been laid down over some disused railway track at Milngavie in Scotland. The total length of this railplane is 425 feet, and the whole of the equipment is full-sized, and not laid on the model principle in which most of the mono-rail systems have begun—and usually ended.

The object which the inventor has in mind is really to obtain a system of high-speed transport, which shall have all the safety of the railway with the speed and form of the airway.

The Zeppelin-shaped car accommodates 50 passengers, and it is driven by propellers placed fore and aft, with the object of attaining a speed of 120 miles an hour. The overhead structure, upon which the wheels of the car will run, is quite an imposing erection of girder work, and the critic, at first sight, would be inclined to say this will be a fatal obstacle to the

adoption of the railplane. This is an age when every effort is made to reduce the cost of transport, and it follows therefore, that any scheme which means a tremendous outlay for track or rolling stock, is doomed to failure, because of the ever-increasing efficiency of the motor on the road, and of aircraft aloft.

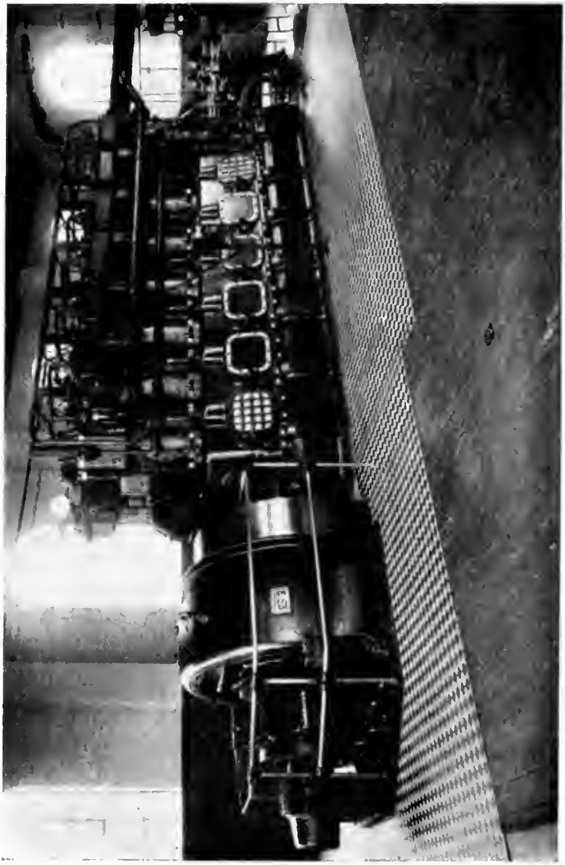
Mr. George Bennie, the inventor of the railplane, believes that there is a great future for it, because he is of the opinion that, for the most part, the overhead track could be erected either above roads or above railways. He points out that the limit of speed on the railway has, in practice, been reached, whilst although aircraft gives a much greater speed, it is subject to atmospheric conditions, which operate adversely too frequently.

Whilst admitting that the first cost will be rather heavy, the inventor claims that once in action, such a railway as this would have very low running expenses. He points out, quite truly, that a tube railway costs considerably more than an elevated one; it

is claimed, therefore, that whilst the usual surface railway is confronted with the difficulty of burrowing through hills and through cuttings in order to keep a level track, the railplane can be carried over any obstacle and the method of propulsion is such that the speed of the car will not be materially affected by quite a substantial gradient.

Not only has the surface railway to be placed in tunnels and cuttings, but there is the enormous cost of embankments in order to secure easy gradients. The great point in favour of the railplane would appear to be the fact that no additional land would have to be taken for its construction; indeed, even where the present roads or rail were not utilised by placing the elevated track above them, it could be carried across fields without seriously affecting their value from an agricultural point of view.

The overhead tracks are carried on trestles which are placed at suitable intervals to support the two rails which are so important. Although the railplane system is described as a mono-railway, it needs to be added



DIESEL ENGINE

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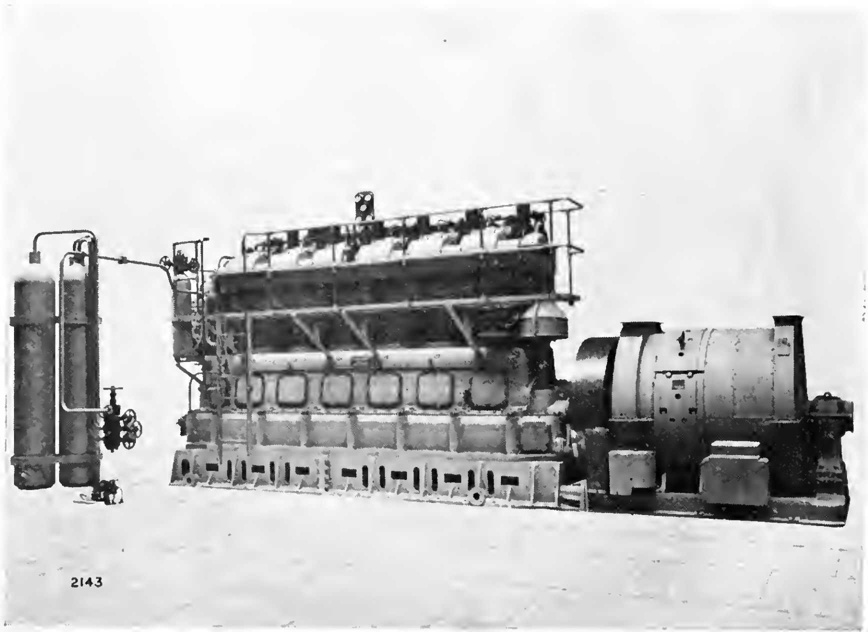

A MARINE TYPE OIL ENGINE [By courtesy of Vickers, Ltd.

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that a guide rail is necessary under the car to prevent undue swaying.

Particular attention has been given to the design of the car which is expected to attain such a remarkable speed. Naturally enough, the car propelled as aircraft is propelled would show a tendency to rise, this, however, is checked by the design of the bogie. These bogies have a very small wheel-base, and there are two to each car, they are placed as close together as possible, so that the undulations of the ground can be followed without any difficulty.

There are eight shock absorbers which are designed to assist in the smooth running of the car, whilst the wheels are carried upon roller bearings. Mr. Bennie has patented a detail which goes a long way to secure a silent wheel. This silence is largely obtained by having an annular ring of rubber interposed between the hub casting and the tyre.

In order to ensure safe travel automatic electric signalling is proposed, and this

would work in combination with a magnetic brake control.

Although the design of the overhead track for the railplane is planned for steel construction, the inventor points out that reinforced concrete, or even timber, can be employed if these are cheaper or more easily obtained. Further, he advocates that an elevated roadway either for fast motor traffic or for pedestrians could be provided without difficulty.

Every effort has been made to reduce friction to a minimum, thus the car itself is stream-lined, just like the gondola of an airship. Running on a single overhead rail, and equipped with modern ball-bearing devices for all rotating parts, there is comparatively little friction to be anticipated.

The air screws are driven by electric motors, whose output is 60 b.h.p. at 1,200 r.p.m. on a one-hour rating. Should it be necessary to stop the car suddenly, this can be done by reversing the car screws, and so easily would the stoppage be made

that the occupants of the car would not feel any discomfort from its abruptness.

In comparison with the construction of tube railways, the Bennie railplane system seems quite inexpensive. It is estimated that the cost per mile of double track for the railplane would be under £20,000, whilst that for underground railway works out at £850,000, and even tramways cost anything up to £37,000 a mile, and the average surface railway at least £60,000.

Mr. Bennie is anxious to see one of his double tracks in operation between Glasgow and Edinburgh, and he claims that the whole of the present passenger traffic could be accommodated by eight cars, which would be so arranged in service that there would be a departure each five minutes, the journey between the two cities taking only twenty minutes.

The critic would immediately seize upon the difficulty of keeping such a large area of girders in proper paint condition. Remembering that the Forth Bridge takes a small army of men constantly at work, it

would seem that a good length of railplane track would be equally expensive in this respect.

Again, the inventor is ready with an answer; he says that the whole of modern progress is to obtain, first, long-lasting enamels and paints, secondly, efficient methods of spraying the paint, and, thirdly, of incorporating in the steel something which will make it rustless such as chronium, although the latter would be out of question at the moment from point of cost.

He does admit, however, that the painting of the track would cost almost as much as its running. A moderate system gives this paint work as costing £200 per mile per annum, or with other details such as signalling stations and so on it would possibly run to £300 per mile per annum.

Each car would require only one attendant, the entrance and exit gates being automatically controlled. The inventor contends that here alone there would be substantial savings in wages costs.

Those who have seen and tested the

experimental railplane lay-out at Milngavie are impressed with its advantages, and at the moment there are at least two schemes under consideration in which the railplane may be adopted as an alternative to a railway.

XV

THE HUMAN SALAMANDERS

We are not thinking now of the real salamanders, those animals endowed with such mysterious powers of fire resistance, if legend is to be credited. Rather do we think of those hard-working fellows who help the glass blower by making his " pots ".

It is perhaps generally known that glass is manufactured from a combination of powdered flints, or possibly fine sand, mixed with various earths, etc. These constituents must be well mixed under very great heat, and here it is necessary to provide something in which this may be accomplished—hence the " pots " provided by the " salamanders ". These pots are made from fire-brick clay, and they must withstand very great heat without bursting or cracking. The fire-brick clay is mined

something after the fashion of coal; indeed, it is usually found in alternate seams with coal. It is not so comfortable down the clay mine, though the coal miner's job is never a pleasant one. But the clay has to be blasted out, and the water is more of a nuisance down a mine in which clay is present.

When the fire-brick clay is brought to the surface it is run off in the small tubs to a shed where the pot-maker, with endless labour, proceeds to fashion it into a pot. There is the mixing stage. An assistant uses his bare feet to render the mass of burnt and unburnt clay into a workable condition.

The work of building up a pot is laborious in the extreme and unless the greatest care were taken there would be a tiny hole which would allow of the molten glass to escape and so ruin the work of the equally patient glass-maker. The pot can be added to only little by little day after day, and no chickens in an incubator have greater care than does the pot as it dries very slowly.

Frost will, in one night, undo the work of weeks, and often the workman must stay up all night to watch his charge, just as the shepherd on the adjacent hills is keeping his vigil too. The pot is built up in layers of about four inches high, and as each layer is added the pot must be left for several days to dry. When it is finished it is grey in colour and resembles something like a small hippopotamus, but without legs. Ten months are required for the pot to dry out, and during this period it needs constant scrutiny to determine whether all is well, whether the drying needs acceleration or retarding, and whether the tiniest crack is visible.

The day comes for its despatch to the glass works, and the greatest care is necessary in handling it. When it arrives at the works it goes into store, there to await the cracking of a pot already in use, though some are so good that they actually wear out without a crack appearing.

The new pot does not pass straight to normal duties; if it did it would most likely

develop that crack which it has been the endeavour of its maker to avoid. The pot is broken in gradually, like a young horse to harness, passing through an oven which is heated only to a certain degree. Passing this preliminary test, it is added to those which have been proved out. The question of when a pot will crack is left to the judgment of the man in charge, and so expert does he become in this deciding that it is rare indeed that, in normal course, a pot gives in whilst in use.

Pot-setting is one of the red letter days —or rather nights—in the glass-house. The man in charge having decided that the old pot must come out of the furnace and be replaced, the staff remains on overtime for a few hours. They have to break open the furnace by pulling down one of its brick sides. The men are prepared for a hectic evening, and they come along armed with strange-looking implements, most of which have quaint names, usually of local origin. The new pot has been tested and is reported

to be in good condition, ready to take the place of the old one.

The glass-house is never a cool place with the furnaces constantly at white heat, but the actual breaking down of a side of the casing which holds the old pot makes the place an inferno. Clothes, as far as possible, are discarded. Working quickly the old pot is brought out by the use of the strange tools, each having its own particular task. For some reason the men shout a medley of instructions, some of which must be disregarded, since one man is obviously contradicting the order given by his mate.

The old pot out, the new one must be put in its place without delay, and certainly without being allowed to cool down, or danger would result, and almost certainly it would crack badly.

With a deftness born of long practice the new pot, weighing at least half a ton, is slid into position, and the aperture through which it was inserted is made good by firebricks, and also wet clay for finish-

ing off round the neck and mouth of the pot.

When the man in charge passes the work as good, the sweating crew are ready to slake their thirst after one of the hottest jobs that a human being is ever called upon to undertake.

The new pot is then ready for its load of material from which fine glass-ware will be produced on the following day to serve and delight the women-folk of this country and many across the seas.

The visitor is warned to keep a reasonable distance from the furnace, and also from the white-hot pots. Many a decent pair of trousers has been hopelessly ruined by coming within reach of the fierce heat.

And that is how the pot-maker and fixer helps to the production of one of our great necessities.

XVI

THE ROMANCE OF THE BARRAGE

FOR many centuries water-power has been neglected, and it is only since coal rose so considerably in price, that the various nations of the world are turning more and more to what is often called, fantastically perhaps, " White coal ".

There are, however, other uses for water-power besides the generation of electricity. Long before electricity had taken the firm hold it has of modern enterprise, the barrage was serving splendidly in various parts of the world, and particularly in Egypt.

Herodotus, some five centuries before Christ, wrote these words " Egypt is a gift of the Nile ". It would seem that Herodotus lived in an age when something of the present system of barrages must have been in existence, perhaps on a greater scale,

most probably on a smaller scale. It is quite true of Egypt to-day, as it was twenty-five centuries since, that she owes everything to that great river, perhaps the most historic in the world.

Those who have travelled through Egypt, and particularly those who know it intimately, are well aware of the wonderful work which has been accomplished by British engineers in that country. There are something like 14,000,000 of Egyptians living on the comparatively narrow margin of irrigated land on either bank of the Nile. Go a little way in either direction from the river, and the desert is entered, yet that fringe of land consists of some of the most fertile soil in the whole world. Its fertility is entirely due to the Nile, and particularly to modern enterprise which has harnessed this great river to serve the needs of man.

There can be no question but that for something like seven thousand years this remarkable stretch of fertile country has been irrigated by the Nile. A wonderful

system of irrigation canals was evolved, and these, together with the annual flooding of the great river, kept the banks green when the rest of the desert was absolutely sterile.

The ancient engineers employed what was called the basin system of irrigation, by means of canals and natural channels they flooded certain sections in such a way that when needed the water could be drawn off and seed planted in the rich alluvial deposit.

Whilst it is usually conceded that Britain has taken a tremendous part in the construction of the Nile barrages, it is well to remember that the real work of making Egypt a much more prosperous country than it had been was begun by the Egyptians themselves in the early part of the nineteenth century. Mohamed Ali introduced the cultivation of the cotton plant, sugar cane, and many kinds of fruit trees which had been unknown in that ancient land.

His first engineers were Egyptians, but many of them had received their training

in Europe. They worked largely under the direction of eminent French engineers, and they began successfully the works which were designed to control the water supply of the Nile. Perhaps the most remarkable of these native built barrages was that of the Delta, which was constructed in 1843.

Another great Egyptian, the Khedive Ismail, who reigned from 1863 to 1879, proceeded further with the work of irrigation. He cut that famous Ismailia Canal, which not only irrigates a very large portion of desert land in the Delta district, but actually carries drinking water to Port Said and the canal zone generally.

Another great canal, the Ibrahimieh, was dug in 1873, and this enabled sugar to be cultivated on a large scale in Upper Egypt.

All this was very excellent, but it did not go far enough, and in 1883 the Government of Egypt summoned well-known Anglo-Indian engineers to advise what could be accomplished in the future, and to re-organise the works which had already been carried out.

One of the first results was the improvement of the Delta barrage, which greatly improved conditions for the agriculturists of that part of Egypt. One of the results of the improvement of the Delta barrage was the tremendous increase in the value of the country which lay around it. Fields trebled in value, and some increased even more so, producing crops which had previously been thought quite impossible to grow in Egypt.

The next step was the construction of the Assuan Dam in 1902. This is one of the finest engineering works ever carried out, and in conjunction with the Assint and the Zifta barrages, a complete revolution in upper Egypt was carried out, and this part of the ancient kingdom made extremely valuable, both to its inhabitants and to the Government.

Not only did the Assuan Dam make things so much better in upper Egypt, but the conservation and then the release of water made possible by its construction resulted in greater prosperity for

all the country below it. Something more was wanted, and in 1908 the Esna barrage was built to improve the water supply of the basins in Upper Egypt. Five years later the Assuan Dam was heightened so that it should hold back very much more water.

Nothing succeeds like success, and the work of the British engineers in Egypt encouraged the native engineers to take a greater interest in their country, and particularly in the various irrigation schemes. They have proved men quick to learn, and well able to carry out the greatest engineering enterprises.

Already the Assuan Dam has been found to be insufficient as regards height, and a very important second heightening has been in progress during the last few years.

Another important barrage, the Nagh Hamadi, has been built, and with each fresh achievement the country has benefited in a remarkable degree.

From Egypt to the Sudan is a long journey, either on land or by river, but

very much shorter of course by air, and now new barrages are proposed in the Sudan which will greatly increase the productivity of that country.

The great barrages are there as permanent monuments of the skill of the engineer, but what is often overlooked is the direct outcome of such work as this. By making land more fertile, a greater population can be maintained in greater comfort. This population can pay larger taxes, which means that the Government has more to spend on social services. Tremendous strides have been made in education and social reform, particularly as regards improvement of health. All this has been possible through the work of the splendid engineers who first designed and then built those monumental barrages which are so important to Egypt.

The most recent of the Nile barrages, the Nagh Hamadi, was opened as recently as December 1930. The work was carried out by a British firm, Sir John Jackson Limited, and it was begun in 1927.

To carry out this great work it was necessary to build dams, called locally *sudds*, to enclose the areas which had to be pumped dry before it was possible to go forward with the permanent work. The condition of the river would allow of this particular side-line of barrage building to be accomplished in only five months out of the twelve. It, therefore, reduced the three years to considerably less if this factor is taken into consideration. Fortunately for Egypt there is no scarcity of labour, and many of the natives made what to them was a small fortune by their work in connection with this important barrage.

Organisation was the secret of this successful venture, and the contractors saw to it that whenever it was possible to go forward with the work, materials were already assembled for the purpose.

A fleet of six tugs, towing 200-ton barges, were working night and day for three years, employed solely in bringing the limestone from the quarries 70 miles downstream to the side of the barrage.

Britain sent out 80,000 tons of cement, and close upon 10,000 of steel sheet piles were required. The barrage represented over 300,000 tons of rubble masonry and concrete, merely for foundations, and over 20,000 concrete blocks, each of which weighed 4½ tons, were placed in the aprons.

Possibly the work could not have been accomplished in so short a time had it not been for the employment of five electrically driven aerial cableways which were established on either bank of the Nile. By this means it was possible to bring the heavy concrete blocks into position, and drop them where required.

Thousands of men were employed, and the work had to go forward at breakneck speed whenever the condition of the river allowed it.

XVII

A CHALLENGER OF THE STEAM LOCOMOTIVE

FOR many years now our railways have been trying to improve upon their method of working heavy, short distance traffic. On the Southern, the problem has been met by the extensive adoption of the live-rail system of electric working. Each year sees a considerable extra mileage electrified, and without doubt the Southern now possess the finest electric suburban services in the world.

The three largest railways of Britain have not advanced nearly so far in the adoption of electric traction. So far as the Great Western is concerned, no effort has yet been made to electrify their lines, save in conjunction with the Metropolitan Railway. The London and North-Eastern have as yet been content with isolated electrifications

in the provinces, and yet theirs is the most pressing problem of all, when we think of the terrible congestion which is daily found at Liverpool Street. On the London, Midland and Scottish, several isolated provincial electrifications have taken place, and one very important scheme in connection with the traffic working from Euston northwards as far as Watford.

In one respect the L.M.S. may claim to have gone considerably farther than the Southern, since they are enabled through their connection with the Underground Railways to work trains originating at Watford right south of the Thames, proving a very considerable boon to the passengers. That is a brief *résumé* of what has been accomplished in the matter of electrification.

But the great problem with all our railways is the question of additional capital, and even when it can be proved that such capital will bring a definite return, there is some trepidation in asking for this subscription in view of the terrific onslaught

on railway traffic made by the motor bus.

This being the case, our railways are making every effort to explore fully alternatives to electric traction. Some success has been achieved already by the adoption of the greatly improved rail motors turned out by such firms as the Clayton Wagons Ltd., and the Sentinel Wagon Co.; both these firms have greatly increased the efficiency of the steam locomotive employed upon the rail coach.

For branch lines where the traffic is not heavy, but yet where a frequent service is demanded, nothing better is likely to be evolved than these self-contained cars. But obviously such vehicles have their limits, and they are quite unsuitable for suburban lines where the traffic is really heavy, and where the only alternative to electrifying them has been the employment of very powerful steam locomotives.

The experiments conducted on the L.M.S. with various locomotives of unique design, such as the turbo-electric, etc., have not

helped to a solution of the suburban traffic, whatever they may have achieved as regards providing a more efficient power unit for express trains.

Within recent months another development towards greater efficiency has been tried by the L.M.S. In this instance one of the usual electric trains has been handed over for conversion to Diesel-electric traction.

Already on the sea the Diesel engine has proved its efficiency and has made railway engineers think whether its power could be utilised for the production of electric current. If so, there would be no reason why an efficient electric train, which would travel anywhere at good speed, could not be provided without recourse to the enormous expense of building power stations and electrifying the tracks. The unit under consideration consists of a Diesel-electric set placed in each motor coach or locomotive.

The experiment has now been under review for several months, and at the outset a gear drive was considered practicable. After

considerable running it was seen that the difficulties of providing a suitable change gear transmission were almost insurmountable; it was therefore determined to have an alternative scheme by which electric transmission took the place of the gear drive.

Many possibilities are envisaged in such a combination as the Diesel engine with electric drive. In the first place there would be nothing to prevent such a combination being employed on lines already electrified. Take, for instance, the Metropolitan Railway which has to depend upon steam *and* electric locomotives for some miles. The train from the city is hauled by an electric locomotive but there comes a point where the electrification of the system ceases. At this station the locomotive must be changed, which, even in the best circumstances, means some slight delay; this delay in the aggregate is quite a serious factor, especially upon such crowded metals as these.

It is claimed by the expert that the Diesel-electric unit would serve admirably for such

a system as this and that it would save the heavy cost of electrifying the remainder of the Metropolitan system. It is suggested that the train might draw its current from the live rail up to the point where it ends, and then the Diesel engine should be coupled up to provide power for the rest of the trip.

There are, of course, some difficulties in the way of the adoption of such a scheme, and there are some engineers who contend that the Diesel-electric unit will have to have considerably longer testing than it has so far been possible to give it. The great point, however, is that the Diesel-electric system could be profitably employed on lines which need electric traction, but for which the cost under present conditions is certainly prohibitive.

In comparison with steam, the balance is very largely in favour of the Diesel engine, nor has progress in the development of the high speed Diesel engine been in any way exhausted. So far from that being the case, these engines are now being made

with an approximate total weight including radiator, fuel tanks, etc., of 20 to 25 lb. per h.p. Such being the case, it is obvious that, per horse-power, the balance is heavily in favour of the motor engine as compared with the heavy and costly steam locomotive.

The general principle of the Diesel-electric vehicle is quite simple. The equipment consists of an engine driving a direct current generator which supplies the current to the traction motors; these are of standard type.

It might be asked, "Why Diesel engines, when the internal combustion motor has been brought to such a high pitch of efficiency, also when the cheapening of petrol has so considerably reduced the cost of running such engines, that there is little to urge against their employment?" It may be pointed out that as on ships the Diesel engine using crude oil results in great economy, so for railway work the cost is much lower than in the employment of petrol, while the efficiency is quite up to the standard of the engine using the latter fuel.

It may be of interest to mention here that the petrol-electric coach, and the petrol-electric locomotive, are by no means new, since a large number of both kinds of vehicles were sent out to France during the War and used with great success behind the lines on the light railways which were built for transport of munitions and stores.

Now to consider the problems involved in connection with Diesel-electric traction. At the outset the power vehicle, whether it is a locomotive or a motor coach, bears a resemblance to the steam engine in that each is self-contained; in addition, the output of its prime mover has a definite limit. In the second place the transmission of power, being electric, is capable of high overloads for limited periods.

Owing to the enormous capacity of a power station when compared with the rating of the rolling-stock motor, ordinary electric stock permits the full advantages of the electric motor to be utilised to the utmost limit. It has been the aim of the designers of the Diesel-electric equipment

to utilise the overload capacity of the electric portion without imposing overloads on the engine, yet at the same time to make the maximum use of the prime mover.

It may be said at once that when compared with the locomotive, the motor-coach problem is really the simpler of the two; thus motor-coach services generally consist of work upon a definite route, the load varying only very slightly due largely to the weight of passengers carried per trip. The difference may be accentuated at times by the addition or withdrawal of a trailer coach, but it is always possible to provide in the electrical equipment certain features which will permit the power equipment to accommodate itself automatically to the required service.

The English Electrical Company have had the whole question of Diesel-electric traction under special notice. They have adopted their own design of equipment for motor coaches, and in it supply the traction motors from a generator provided with two fields. One field is excited at approximately

constant voltage from a direct driven exciter, or, in certain circumstances, from a battery. The second field is a series field, acting in opposition to the shunt field.

Taking as an example a 200-h.p. equipment, it will be found that the reverse series field automatically limits the currents which can be applied to the traction motors, even when starting from rest. Thus there is no possibility, by faulty manipulation on the part of the driver, of obtaining too great an acceleration or of spinning the wheels. It should also be noted that no starting resistance is required in the motor circuit. Further, the shape of the output curve of the generator is such that over a wide range of speed the engine is being utilised at or near its maximum output. At the same time, however, the engine cannot be overloaded.

The control of the power given by the generator to the traction motors can be varied either by control of the engine speed, or by control of the field of the generator. A combination of these two methods is

found to provide the simplest and the most economical method of control.

Other points in which motor coach operation differs from that of the locomotive is found in certain details, particularly in cases of multiple-unit operation. Thus it may be desirable that all the operations connected with starting up and shutting down the Diesel engine shall be controlled from any of the driver's compartments.

This can be quite easily arranged for on the driving controller, so that the operator has one control only to manipulate. Two additional notches are provided on the master controller, and these are provided with interlocks, so that they are inoperative so long as the driver wishes to keep the engine running. The master controller can in addition be provided with the usual deadman's handle, the operation of which opens all the circuits, shuts down the engine and applies the brakes. It is in effect absolutely fool-proof, and neither the engine nor the electrical equipment can be overloaded.

The pioneer Diesel-electric set built by the English Electrical Company is to the order of the L.M.S.

The 500-h.p. engine is of the Beardmore type, which has eight cylinders, the engine being coupled to a 340 k.w. 600-volt generator and a 8 k.w. exciter.

The conversion of a unit of the electric stock used on the Manchester–Bury line to Diesel-electric propulsion has been carried out by the engineering staff of the railway. The engine has four speeds and the generator supplies power to two traction motors, each of 280-h.p. mounted on one of the motor coach bogies. In normal services the motor coach will operate with three trailer coaches, making a compact and useful train with driving compartments at either end.

A 120-volt battery consisting of 60 cells is provided for starting the engine. The battery is connected by means of a change-over switch to the generator; the latter acts as a motor, and rotates the set until the engine commences to fire. The battery is then disconnected from the generator. In

THE GAILLARD CUT, PANAMA CANAL

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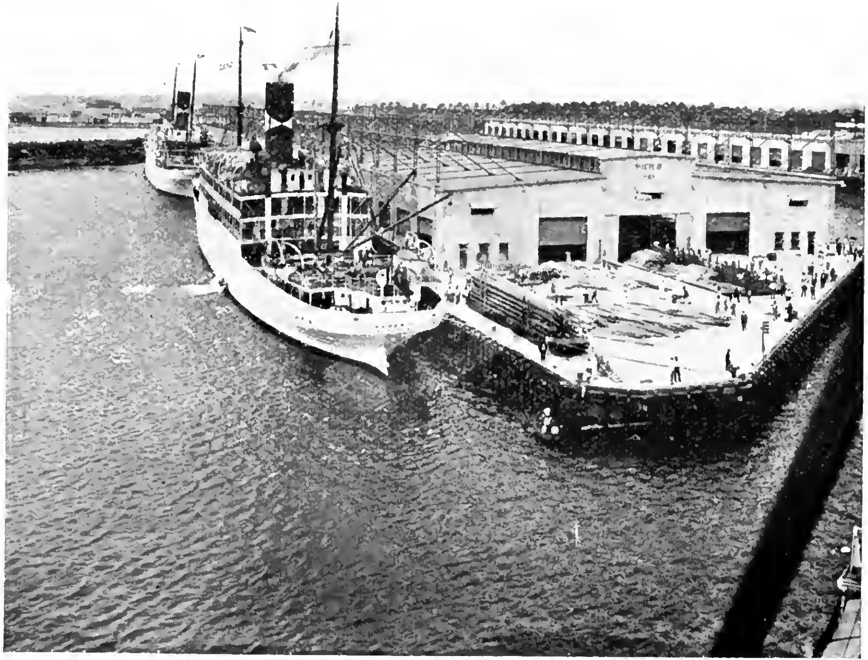

[By courtesy of the Director, Canal Zone.

THE CRISTOBAL TERMINAL DOCKS, PANAMA CANAL

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addition to this the battery, under certain conditions, supplies the lighting and control current, also the power for driving the exhauster motors. Normally these supplies are provided by the exciter, but as the latter is driven by a variable speed engine, arrangements have to be made to provide them from the battery whenever the exciter voltage drops below a certain limit.

Each motor-coach is 52 feet long and unloaded, it weighs 33 tons. It is provided with a control compartment at each end, and one baggage, one first, and one second class compartment. The coaches are painted in the well-known red uniform of the L.M.S., and the whole train is a very fine example of what may be accomplished in such a conversion as that described.

XVIII

THE MARVELLOUS TELE-WRITER

There are many wonderful instruments at work in London's great telegraph office at St. Martin's-le-Grand, but the most remarkable—to the visitor at any rate—is the tele-writer, because it seems almost human.

There is nothing much to see until the machine begins to work, and then it is most uncanny. A pen is held against a block of paper and suddenly it begins to move and letter after letter is written in a flowing hand. More remarkable still is the wonderful way in which the pen, having reached the end of a line, begins another but first takes a dip in a small inkpot.

This curious instrument is reproducing in the big Telegraph Office in London the message which is being written by a city

man in his office perhaps half a mile away. He employs this method of sending his telegrams rather than telephone them, or sending a messenger with the written form. The latter method takes too long now-a-days when streets have to be crossed which are filled with traffic.

When the telegram is written by the magic pen the form is torn off the pad, and most probably the pen begins another message—to an entirely different town most likely.

The form travels along by means of a conveyer and here is another curious and wonderful arrangement of controls, for it drops down to the telegraphist upon whose instrument it is due to be despatched.

XIX

THE ROMANCE OF THE PANAMA CANAL

THERE is a strong probability that there will be a second Panama Canal cut through that narrow stretch of land which divides the two Americas. The United States Government is now considering the matter. That such a vast expenditure can be contemplated is sufficient proof that the present canal has fulfilled expectations, and that the traffic attracted to the isthmus is so great that a single waterway will no longer suffice. Yet how strange it is to reflect that the first attempt at a canal across the Isthmus of Panama should have been a complete fiasco, involving many people in serious losses and even ruin.

The French had been very successful with the Suez Canal, and it is not surprising therefore that they turned to fresh fields

for conquest. That a canal might be cut across Panama had long been envisaged; indeed, in 1850, the governments of Britain and the United States concluded a treaty under which the complete neutrality of any canal across this portion of America should be guaranteed.

Nothing was done as to the cutting of the canal until some years after the Suez venture had been carried to a successful conclusion. The Colombian government were approached and they readily undertook to give the land for the canal on the condition that at the end of 99 years the waterway would revert to the country.

Other conditions were that the canal could not be transferred to any other nation and that it should be completed within twelve years. When it was known that M. Ferdinand de Lesseps had consented to take charge of the scheme, to visit the site of the proposed canal, and then to supervise its construction, money flowed in and confidence ran high. There was some

difference in opinion as to whether the canal should be cut at sea level or be locked, de Lesseps favouring the former as in the case of the Suez waterway.

There were many causes for the wholesale failure of the scheme, not the least being the corruption which crept into the enterprise. Everywhere money was spent lavishly and often unnecessarily. The estimates were proved to be wholly unreliable; the survey was too perfunctory, whilst the health factor seems to have been completely overlooked. That deadly climate took a terrible toll of the workers. It is summed up by saying that in the worst of the seasons forty people daily were being buried in cemeteries which were soon overcrowded.

Although the venture was badly planned and carried out with a tremendous amount of extravagant outlay in fees and appliances, the work went on steadily for several years. Then, at last, de Lesseps admitted that he had not allowed sufficiently for the tropical rains which caused small streams to become

temporarily very swollen rivers; these discharged their waters into the partially excavated canal and held up progress. Although a good deal of excavation was carried out the main portions of hard rock, like the celebrated Culebra Cut were not tackled, and this, it was known, would seriously test the workers and their machinery.

In 1889 de Lesseps was compelled to resign and some attempt was made to reorganise the company and also the scheme. It was too late, though it must be confessed that in some respects the engineers made plans which were carried out later on when the Americans had to attempt this great problem.

Great interest had been roused in the United States because it was quite clear that a Panama Canal would vastly affect that country's trade and naval position. There were insistent voices raised that such a colossal venture as this should not be in the hands of any European power, nor yet should it be financed from across the

Atlantic. A large section of the United States people expressed the opinion that this should be a great national undertaking, carried through at whatever cost might be necessary, and that it should not be regarded primarily as a money making concern.

A commission was appointed to go into the whole question, and they at first found in favour of a canal which would include Lake Nicaragua, which, whilst not so difficult in some respects as the one planned by de Lesseps, would nevertheless mean a length of over 183 miles to be navigated between ocean and ocean. The cost was estimated at £40,000,000, which was less than had been squandered upon the unfinished French venture.

When the liquidators of the French company heard of this counter proposal they became very anxious to sell their enterprise, such as it was, to the United States government, and finally President Roosevelt came to terms which saved a little for the poor French shareholders. The next step was to come to an agreement with the Colombian

government, not an easy matter by any means. One of the first demands of the U.S.A. government—and one which was very necessary to allow them complete freedom of action—was the making over of a belt of Colombian territory six miles wide to come under the Stars and Stripes.

It was a delicate matter to negotiate a treaty which would not offend the susceptibilities of the Colombians over the ceded territory. But the leaders of the smaller country were not unmindful of the rich monetary bait; more particularly they saw in the successful cutting of the canal an increased prosperity for the country generally, whilst the towns and villages near the canal zone would be benefited both during the construction and later on when traffic was passing regularly to and fro.

Once the treaty had been made the American engineers got busy with their plans, which meant a virtual scrapping of the work already carried out. They looked far ahead, seeing that even if the cargo ship did not increase greatly in length and

depth, the liner and warship most certainly would.

Therefore a minimum depth of 35 feet was determined upon with a minimum width at the bottom of 150 feet. At every turn in the course of the canal it was decided that widening on the usual minimum should be undertaken in order that the ships could be steered more easily and without endangering themselves or the banks of the canal. A waterway 50 miles in length was necessary though the width of the isthmus at its narrowest point is considerably less than that. From the Atlantic the canal pursues an even bed for some miles.

Then come the Gates of Gatun, where the ship must ascend 85 feet for the next stage of her trip through the waterway. Here is a very fine engineering achievement, involving three successive locks for this big difference in levels. In view of the very serious damage which would result if a ship collided with the sides of the lock, and a possible block as the result, all vessels must be towed through the locks by electric

locomotives which run upon a railway on the bank. To avoid any misapprehension as to the use of the ship's propelling machinery an official comes on board as the locks are approached and goes below to seal up the engines.

The next stage is across the Gatun Lake—easily the largest lake ever created artificially. So vast is it that all the navies of the world could find safe anchorage there and still leave abundant space for the mercantile marines of the earth.

It is strange to reflect as one passes through Gatun Lake that only a few years back it was a deep valley, singularly fatal to any but natives on account of the fevers which seemed to lurk there. In point of fact the first conquest of the American engineers was this fever-stricken region. Not a turf was turned until the Chief Medical Officer reported " All clear ". The fight against fever was carried on unceasingly for many months and those devoted men, risking their own lives, made the territory safe for the canal constructors.

Every stagnant piece of water was either abolished or so treated that the deadly mosquito found no safe hiding place for her eggs. Malaria and yellow fever had been tracked down to this hateful insect, and though perhaps no one would yet consider the canal zone a health resort it is fortunately true that white men are free far more there from the disadvantages of a tropical climate than in many other parts of the New World.

Gatun Lake is rather a favourite stretch of water with shipowners for they find here some recompense for the necessarily heavy tolls which they must pay. The water of Gatun Lake has this curious property that it dissolves very quickly the marine growths upon the hull of a vessel which so tend to slow her speed. The period between dry docking a ship that uses regularly the Panama Canal may be extended considerably through this strange property of Gatun water.

In length the lake is about 23 miles, and from it the ship enters the celebrated

Culebra Cut—an obstacle that seemed so terrific to the French engineers, and by no means easy for their successors. When in progress the work was constantly held up and the men and machinery threatened by terrific landslides. One of these deposited thirty million cubic yards of rock and earth upon the excavation which had been prepared. With the landslide went houses and machinery. It took two years to clear up this trifle, and held up the canal to that extent.

The Cut is nine miles in length, and the whole of its course had to be prepared with the greatest care; even so there were many occasions in which the water disappeared as if by magic and there were curious hillocks in the middle of the course, upheavals which had not been there the day before, and were doubtless caused by subterranean pressure. Another set of locks is now encountered and these lower the ship into still another lake—that of Miraflores, an expanse of water less in size but of greater beauty than Gatun Lake. After

passing another section of the canal the final set of locks is reached, and these place the vessel upon Pacific Ocean level.

Of all the marvels of this feat of engineering the locks and their machinery are the greatest. In these clever brains were allied with skilful hands. Electricity is employed to a greater extent than in any similar undertaking. Thus, there are more than 200 distinct electric motors employed in the lock houses, whilst there are the useful and exceedingly handy electric locomotives, already mentioned as employed upon towing duties. Placed end to end the locks would measure 6,000 feet and 60 motors are devoted to the opening and closing of the gates.

There is a central control house, in which the engineer in charge for the time being, can see at a glance exactly what is happening at every lock, the state of the water and the number of ships in course of transit being shown upon the charts and dials. Never was work so concentrated as here.

The Panama Canal is indeed a monument to the public spirit of the citizens and the skill of the engineers of the United States, likewise a blessing to every nation of the world.

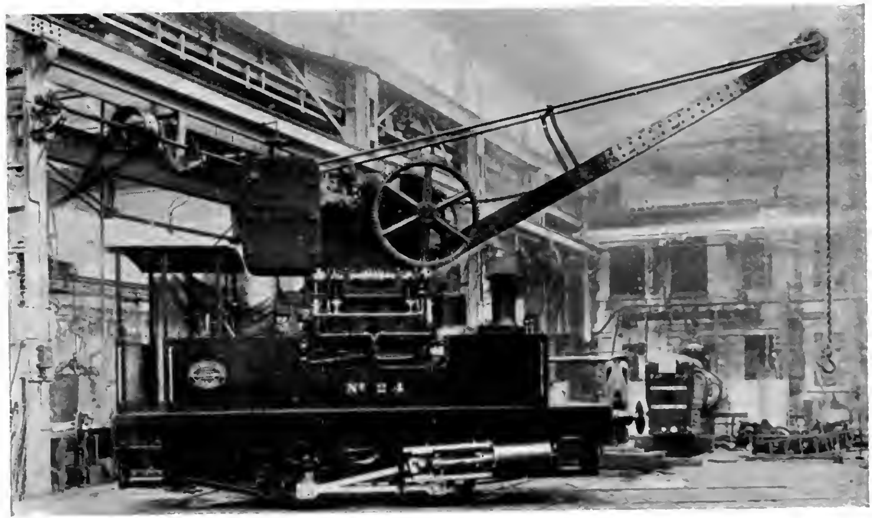
XX

THE DEVELOPMENT OF THE STATIONARY ENGINE

The constant improvement of the stationary steam engine is often overlooked because of the more spectacular achievements of the locomotive, or again by the greater efficiency attained afloat with both turbine and reciprocating engines. Here are some of the useful improvements made in recent years with stationary engines depending upon steam.

The Question of Efficiency and Economical Lubrication

The idea of enclosing an engine as a means of preventing the oil being thrown about the place originated during the watch-



A LOCOMOTIVE CRANE
These Cranes are extensively used in Railway Works

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Picking up the Mails [By courtesy of G.P.O.

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ing of the operation of a ship's auxiliary, and one was immediately constructed on these lines, and run at a considerable higher speed than had hitherto been possible. It became apparent at once that another means, other than by splash, must be employed to convey oil to the working parts, and in 1890 the introduction of the totally enclosed engine using forced lubrication revolutionised engine practice.

Since this first engine, one British firm alone has constructed upwards of 8,400 on the same principle, of horse-power varying from 10 to 2,500, and speeds varying from 1,500 to 200 revolutions. These engines operate with the minimum of vibration and noise under all conditions, and are equally suitable for use as back-pressure or pass-out as they are for condensing conditions.

Pass-out Turbines

Then there is the constant improvement in the non-reciprocating engine of which

perhaps the pass-out turbine is the best example for all round stationary work.

The main principle of this method of working is that the low pressure steam, as extracted from the turbine, is allowed to do work in the high pressure stage first.

It also does away with a high back-pressure turbine which is very inefficient. The main advantage of this type of turbine is found in cases where the demand for low-pressure steam does not correspond with the load, or where the demand is not constant.

Under such conditions, it would appear that governing would be a very difficult thing, but with a specially designed oil relay governor, on which an isochronous gear is superimposed, governing is brought within the ordinary limits, and hunting is non-existent.

The method of controlling the amount of steam being passed out is by means of a ported gate, the ports being set in such a way as never to allow them to close, this

being made necessary by the fact that the turbine is exhausting to a condenser. The steam consumption of these turbines is very little more than an ordinary turbine for any given load, of course, taking into account the amount of steam being passed out. Such turbines are now available up to about 7,000 k.w.

Diesel Engines

Diesel engines have been available for many years now, and recently one was brought out as a totally enclosed high-speed engine, being made in three standards. These three standards can be modified and varied to meet most requirements between 150 and 1,000 k.w. They are of the land type, being particularly suitable for driving electric generators, and are easily adaptable for shipboard use. They embody all the experience gained in the manufacture of high-speed reciprocating steam engines over a period of many years, and the forced

lubrication system is applied to every bearing.

These engines are of the air injection type, are single acting, operating on the four stroke cycle, the piston being of the trunk type. The air compressor is of the three-stage type, with coolers after each compression, the delivery pressure being up to a 1,000 lb. per square inch, and there is a pressure and output control on the intake valve.

The compressor is driven by an overhung crank at one end of the main shaft, and is mounted on an extension of the main engine bed-plate. Since these engines run at higher speeds than are usual, provision is made for cooling the piston head and exhaust valves by oil when conditions make this necessary. Always, on the larger standards, the exhaust valve seats are water cooled.

The high-speed Diesel engine offers many advantages over the low-speed engine, the chief of which are more power from the same space, less head room required on

account of the shorter stroke, this being necessary to keep the piston speed within recognised limits, and the lower cost of the generator (this assuming that the engine is direct coupled to a generator or alternator).

XXI

HOW THE ENGINEER HELPS THE RAILWAY

SOME remarkably good locomotive tractors have been designed and placed on the market by M. Gaston Moyse, of Paris. These machines have been tried at various goods depots of the French Railways; having proved successful there, they have been experimented with in various industrial works.

Many attempts at the adoption of internal combustion type locomotives have been made, and although a fair amount of success has been achieved there have been found inherent difficulties, such as lack of elasticity or flexibility in the gear for the transmission of the power generated by the engine, in other words the difficulty has been to secure an easy application of power.

M. Moyse has adopted electric transmission, and has thus secured traction units which possess practically the elasticity of a steam locomotive. The power unit of the new locomotive tractor consists of a four-cylinder Panhard-Levassor petrol motor; this drives direct an electric generator of Thomson-Houston construction, which delivers direct current for operating the two closed motors, one of which is applied to each of the two axles of the locomotive.

By the adoption of this electrical manœuvring gear, the locomotive can exert a hauling effort up to any figure within 10,000 lb. in either direction forward or backward. In addition it can exert a maximum tractive effort at three miles per hour of nearly 9,500 lb. In running order the weight of the locomotive tractor is 20 tons and it works up to a maximum speed of 15 miles per hour. The total length over buffers is 22 feet, while the wheel-base is 9 feet only. Under test it has been found that this handy machine can handle satisfactorily a

load of 700 tons on the level at an approximate speed of 3 miles per hour, a speed, by the way, which is adequate for most shunting work.

The locomotive tractor has also been able to deal with a load of 150 tons up to a grade of 1 in 50.

The new machine has been designed to conform to all the requirements of the standards laid down by the Berne Convention. In order that the locomotive tractor may be efficiently braked, Westinghouse air brake apparatus is provided; in order that shunting may go forward in darkness, the machine is adequately lighted by electricity. Special attention has been given to the provision of an efficient lubrication system; all fittings for this purpose have received most careful supervision.

In many directions efforts are being made to supplant the steam locomotive, and it would seem that for shunting duties at any rate, the internal combustion machine is likely to prove the most suitable substitute. Thus compared with the steam locomotive,

the locomotive tractor under review has the following distinct advantages: There is no pressure plant such as boiler, etc., to be looked after, neither is the water supply essential; as with all the internal combustion machines there is no waste of fuel when the engine is standing idle. Most of all, one man only is required as a driver, no fireman being necessary.

Another advantage is the absence of smoke and the lessened risk of fire from sparks and ashes found with the usual type of locomotive. Although the Moyse productions have been mostly seen upon the Continent, the Michelin Company, of Etruria, Stoke-on-Trent, Staffordshire, has introduced one of these locomotive tractors with great success.

Further experiments towards providing an alternative to the usual type of steam locomotive have been carried out by the Atkinson-Walker Wagons Ltd., of Preston, England, and several very good types of rail tractors have been produced from their works. It goes without saying that the

ordinary type of locomotive found on our railways, is, while a most efficient machine, also a very expensive one, not only in its first cost, but in running. We have only to consider the boiler, for instance, to realise that it is far from an economical steam producer; in addition there is a great deal of its area exposed to the air, and at speed, the air takes a very heavy toll of its heat.

Then consider, for a moment, the reciprocating operations of the locomotive, apart from the wear and tear, which is naturally very heavy, there is a very certain deterioration caused by the dust and cinders which pass to the most delicate parts of the locomotive's anatomy. For the rail tractor, such as the Atkinson-Walker, many claims are made, and careful analysis of them shows that they are well based. Not only is the first cost of such a machine very much less than a locomotive performing similar work, but it is more especially true that the maintenance charges are much lower. The builders guarantee that the fuel

consumption will be more than halved, and the lubricating costs approximately one-fourth.

By adopting an automatic lubricating system there is no time lost in standing by for oiling up. The whole of the working parts are adequately protected from track grit; the boiler is as indestructible as it is possible for a boiler to be, and it is pressed to produce a high-pressure dry steam. Then it is possible to halve the size of the boiler, and also to protect it thoroughly against radiation. Steam is raised in about half the time as compared with the usual type of locomotive, and, taking the power exerted, the weight is certainly less. From a working point of view there is the gain that one man can give adequate attention, the fireman being dispensed with.

In the Atkinson-Walker rail tractor the engine is placed vertically, right under the driver's eye; it runs at a much greater speed than the driving wheels, and the claim is made that as a consequence it asserts great starting effort. The steam is distributed on

the uniflow principle which is simplicity itself, besides ensuring economy; the engine is easily reversed, and eccentrics, radial valve gear, piston or slide valves are absent. The makers supply their own steam valves (there are no exhausts), and these only require facing, grinding or ring renewal.

In place of the usual side coupling rods, with their rather complicated joints, we find simple roller chains. The boiler is rather small, of a vertical type, fitted with water tubes; it is especially well lagged and protected from draughts. It is built of steel throughout, and consists of a two-piece welded structure without screwed stays, steam-joints, rivets or crown bridges, and it is so arranged that by breaking two joints it may be taken easily apart for cleaning the steam and water spaces. As far as the fire-box can be made indestructible that of the rail tractor may be so classed, the only parts of the boiler proper which require renewal are the water tubes; these are short and are very easily replaced.

One notices at once the absence of a furnace door of the usual type, and it is found that stoking is done through a chute in the foot-plate, but there is a small door in front which is found very handy for lighting up and removing clinker. The valve gear consists of one cam-shaft only and there are no exhaust valves. The great feature of the design is that the hot steam entering the cylinders at each end flows in one direction only, that is towards the exhaust ports. One result of this arrangement is a uniformly decreasing temperature from each end to the middle of the cylinder barrel; it is this peculiarity which may be said to account to a very large extent for the high economy of the engine.

In the ordinary type of locomotive, the ends of the cylinders are alternately heated and cooled because the cold exhaust has to be expelled from the same end through which the hot steam was admitted, the net result of such an arrangement is that more coal is required, and if it is not really needed, then it is certainly

wasted. It goes without saying that the boiler of a self-propelled vehicle is its most important component, and the greatest attention must be given to its construction.

The fire-box of the Atkinson-Walker rail tractor is especially efficient; it is made of steel without stays or rivets; it is circular in form, squared in its upper parts to receive the tubes, but its lower flange and firing and clinkering openings are welded to the bottom portion of the outer shell, the top portion of the outer shell, by the way, is removable for cleaning inside. The circulation is most rapid, and as the insides of the tubes and the outside of the fire-box can be kept clean, the steaming power of the boiler and its original working pressure remain practically unimpaired during its life-time. The superheater is of rather a unique form, consisting of a solid steel tube placed right in the way of the hot gases. The special firing device mentioned above conduces to coolness in the cab, and totally prevents glare from the furnace.

A feed-water heater of an efficient unbreakable yet easily cleanable type is fitted, the feed pump is of the Duplex slow speed type. For such a small locomotive the water tank may be described as of generous capacity. In addition to the usual man and hand-holes an accessible, cleanable strainer is provided in the delivery pipe; each axle is driven by adjustable roller chains from a cross shaft by the engine and crankshaft through a pair of bevel spur wheels.

The axles are of high tensile steel, accurately ground in the journals; for the axle boxes cast steel, bronze bushed is employed; these are automatically lubricated. The driving wheels have centres of mild steel with separate mild steel tyres; the brake gear is operated both by hand and steam power; sanding gear of a very simple pattern is provided, whilst the buffing gear is of standard design for work with rolling-stock of the normal type. The suspension gear is of the usual semi-elliptic spring type.

The Great Southern Railway of Ireland have recently placed in service several Drewry internal combustion rail cars for branch lines and intermittent passenger services on the main lines. These coaches appear to be the very type of inexpensive unit for working such lines as are found in Ireland where traffic has never been too heavy.

The running costs are low, and even if they load up to less than half capacity it has been proved that they will pay their way. Two types of the Drewry rail car have been supplied by the makers from their Burton-on-Trent works; one of them is of the 70–75 h.p. four-wheeled coach for the $5\frac{1}{4}$ feet gauge. It was stipulated that this car should give up to a speed of 40 miles an hour on the level, and yet be able to attain a rate of 20 miles an hour up a gradient of 1 in 75. They have accommodation for 30 passengers, and it is estimated that the total running costs amount to less than one shilling per mile. This type of car is fitted with a 6-cylinder water-cooled

engine, having cylinders 5×6 inches, and developing up to 75 h.p. at 1,000 revolutions per minute.

Controls are mounted at either end of the car so that it can be driven equally well in either direction. These controls consist of reverse and change speed levers, foot accelerator, foot brake acting on the drum of the reverse shaft, and hand lever brake, working direct on to the carrying wheels. The main frame is of steel channel provided with an inner frame to carry the engine and gear box. The body of the car is of teak with steel panels outside, finished with venesta ply-wood inside up to the waist-line. The side lights are arranged to drop and the reversible seats are covered in rattan.

The roof is the usual type; dynamo, electric lighting, and self-starter sets are fitted, these include head and tail lights and interior roof lights. The steel water and petrol tanks accommodate 40 and 20 gallons respectively. The wheels are 30 inches in diameter, and are of the rolled-steel disc pattern.

To work upon the 3-ft. gauge track some smaller Drewry cars have been built, these are 40–45 h.p., and except that they are smaller and lighter, they follow generally the details of the broad gauge cars. These rail cars have already proved to be extremely economical, and those employed on the narrow gauge show a total working cost which is under ninepence a mile.

XXII

SNAPPING THE MAILS

CLICK! Thud!

Those are the noises heard as the big mail train flashes by the trackside apparatus for the exchange of mails.

Click, thud, is heard throughout the night as the train hastens on its journey from London to Aberdeen, whilst the sorters aboard the mail are working against time.

"How do the men know when to put the bags ready on the standard for the trackside net to take off?" is a question that has often been asked.

In the daytime, of course, they can watch various signs by the side of the railway, or they may pass under or over a certain bridge. But at night there is nothing to be seen, save perhaps the lights of a village or town.

The mailmen know where they are exactly by the sounds made by the train. Each bridge passed over has its own particular sound, each cutting through which the train is rushing has a note all of its own.

As an exchange point is reached the men within the mail van put whatever bags are due to go into one or more stout leather pouches. As many as four light mail bags can go in a single pouch. The pouch is strapped ready, and is then clipped upon the standard. When the sound of the railway tells the man in charge that the train is rapidly approaching the exchange point, he pushes out the standard with its two or three pouches, and at the same time drops a net from the side of the van. Then an electric bell begins to ring; it says "As you value your life, do not pass this spot!"

No wonder, for there is the usual click and the thud, and something black comes flying into the mail van through the open door.

It is the pouch picked up from the trackside standard. Mails have been exchanged at sixty miles an hour!

XXIII

THE ROMANCE OF THE BOX

THE wooden box in which our soap, sugar, or other articles of domestic use is received, represents a remarkable achievement. It is one of those things to which we give little thought, and yet a casual glance shows that a good deal of consideration has been given to the making of this useful accessory of commerce.

As a rule, the life of a wooden box is quite a short one, possibly it is sent to the grocers by the wholesale firm, containing soap, or some other similar commodity, and then passes to the housewife for a few coppers to be broken up for firewood. On the other hand, there are some boxes which seem to bear a charmed life, and serve either for their original purpose again and again, or become perhaps the platform for an

orator at a street corner, or again for use as the body of the errand boy's delivery vehicle.

It will be at once apparent that the timber for the ordinary wooden box could not be grown at home in sufficient quantities to suit the needs of perhaps a single firm, such as Lever Brothers, therefore, many a cargo of timber finds its way to these shores which will be devoted entirely to the production of the common soap box.

Whilst most of this timber comes from northern Europe, and Scandinavia in particular, practically every country, except perhaps France and Italy, contributes its quota to the works of the English box maker.

In this country, the question of reafforestation has only become acute since the War, and even now there are many deploring that we do not do more with our waste land than allow it to remain treeless. In Scandinavia, however, the wealth of the forest is fully appreciated, and there is a law which ensures that for every tree cut down at least one must take its place.

There is a limitation placed on the amount of timber cut, and care is taken that, so far as can be seen, the yearly supply will be made without rendering the countryside bare of its trees.

For box making the timber obtained from spruces and firs is preferable to any other kind. The Norwegian spruce, sometimes called the White fir, is the tallest of European firs, often growing to a height of 60 feet. Then there is the northern pine, of which there are tremendous forests in Russia and Scandinavia generally. Whilst the Norwegian spruce produces a very light yellowish-white timber, the northern pine gives wood which is best described as a light reddish-yellow.

Either of these kinds of wood should be obtained from trees not less than sixty years old; if they are older so much the better. The reason for this is the need for obtaining heart wood rather than sap wood, the latter being the growth of recent years. In a young tree the bulk of the timber would come under the term sap wood, and

it is so soft as not to be worth export. On the other hand, it would never do to allow the tree to become degenerate before it was felled. It is obvious, therefore, that if forests are properly cared for and their trees planted in sections year by year, a succession of timber of exactly the right age will be available.

In the forests there will be found the wood-cutters' camp, and almost invariably this camp will be pitched as near to a stream or a creek as possible. Naturally enough, there is no cheaper method of transporting timber than by water, and although the streams and creeks will not penetrate into the interior of the forests, it is often possible to carry forward the work so that the men are never far from water.

A good deal of the felling is done in the winter months. When the trees are cut down they are first trimmed of their bark and branches, then the trunks are loaded on to sledges and pulled over the snow by horses until the nearest water is reached. As a rule, no effort is made to ship the

timber during the winter, the getting down the stream or creek can be safely left until the spring, mainly because the streams will be full of water from the melting snow, and thus make it considerably easier to get the timber to the port of shipment.

It is said that some of the timber is frequently as much as two years in course of transit to the coastal mills placed at the estuary of practically every river. In Scandinavia there will be found a timber pool, and from it will be taken constant supplies for the use of the saw mills which border the pool. Here the trunks are cut up into what are called boards, battens and deals. So far as possible it is arranged to cut the timber into thin planks which will require very little further cutting to adapt them for boxes.

To show the enormous demand made upon the saw mills it may be mentioned that the great firm of Lever Brothers need something like six million sections of box parts every year, and it will, therefore, be appreciated that their timber arrives by the

ship load, and is stored in huge quantities at Port Sunlight until it is actually required.

Having seen how the timber reaches Britain for one of the largest firms using boxes, let us now see how the engineer has been brought into the business of box production on a large scale. Time was when the making of a box would have been a carpenter's job, now it may safely be said that it is essentially the work of the engineer.

He it is who has evolved that wonderful machinery which takes the plank, and with a very few processes, converts it into a box, printed with the name and address of the user, and in many cases some instructions as regards the quantity and quality of the future contents. In the case of such a firm as we have in mind, whose trade is world-wide, it follows that several languages are used for giving this important information.

Strangely enough, the first operation in box making is to print the necessary particulars upon the wood before anything else is done. Clever machinery has been devised which cuts to the exact size the sides, ends, bottom

and lids of the boxes. The cutting, although it seems so simple, involves some remarkable dove-tailing of the ends and sides, for these boxes will have to stand a great deal of hard usage before they are delivered to their destination.

The sides and ends having been dove-tailed, the box passes on for the next operation, which consists of nailing on the bottoms, but this is not done by hand, for the engineer has evolved a clever tool which is well named the automatic nailer. It is in charge of an operator who is enabled to turn out scores of boxes each hour.

All that he has to do is to pick up the framework of the box as it reaches him, select three bottom boards, place them into position, press a foot treadle, reverse the box, press again, and hey presto! the box is made. The machinery feeds itself from a flow of nails which descend by a series of tubes; they always arrive with the sharp point downwards, then they glide into the slots and so the automatic nailer is constantly fed with the necessary supplies.

The boxes which have to go abroad are further strengthened by having small bars nailed across them, this work is also accomplished by clever automatic machinery.

The boxes are now ready for their contents, and directly these have been packed safely inside there is another machine waiting to nail on the lids. This is largely a replica of the machine which did the work of nailing on the bottoms.

Everything seems to go so smoothly that, as with many other details in life, we are apt to take the whole business for granted; but it is well to give a thought to the clever brains which visualised each of these operations and then perfected the machinery to carry them out.

XXIV

THE WONDERFUL FATHOMETER

THERE is a story still told of how a stoker on board a famous Cunarder was startled out of a prosaic existence by hearing a very loud and heavy thump right under his feet. The ship had left port two hours before and was far away from the land.

A little later the thump was repeated again so there was no question of a mistaken impression on the part of the stoker. He was now alarmed and could only conclude one of two things; the first that the ship was hitting against some sunken wreckage, or alternatively that some poor fellow engaged in the false bottom, or in a tank had been trapped and was using his hammer to summon assistance.

The stoker called the engineer and he began to laugh, greatly to the annoyance of

the fellow, who now suspected a case of leg-pulling; instead, it was explained to him that the liner had now been equipped with the recently invented Fathometer. This is a most ingenious piece of apparatus; indeed, it is claimed to be the greatest advance since the gyro compass or direction finding by wireless were introduced. As its name may have suggested, it is an instrument for finding out how many fathoms of water there are underneath a ship.

Naturally such an instrument is rather complicated, and it consists of three distinct main parts. They are divided as follows:

The Indicator on the bridge, comprising a dial which has a clock-like face divided into fathoms, beginning at 0 and running up to 130, is the visible termination of the apparatus.

A fathom is, of course, six feet. The dial on the bridge is connected with a delicate microphone placed in the bottom of the ship. A wire connects it with the bridge apparatus. The microphone is very sensi-

tive and picks up the echoes from the bottom of the sea. These echoes come from blows (which the stoker heard) made by a hammer on the plating of the vessel's bottom.

When the mechanism is set the hammer strikes about each three seconds and the sound of the blow travels to the bottom of the sea, and then gives back the echo which is transmitted, via the microphone, to the bridge. It has been known for some time that sound travels through water at a uniform rate of 4,714 feet per second. The mechanism is arranged to give regular blows at the intervals mentioned, whilst another very delicate piece of apparatus measures the time taken by the echo to reach the microphone; by that means the depth of the water under the ship is known to a foot.

The Fathometer is only set to work when the liner is within a reasonable distance of the coast and fog or mist supervenes. In clear weather going into or leaving port the pilot is able to know exactly where he is;

in bad weather he had to take an awful responsibility if he kept on, whereas if he advised anchoring there was a fairly good risk of the liner being run down by some vessel which had not taken the same precaution.

Fog is gradually losing its terrors for the skipper of the big liner, and we may imagine with what anxious eyes the dial of the Fathometer is watched, a red flash at the marked portion telling the observer the exact depth of water.

THE END

A LIST OF BOOKS

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Louisa M. Alcott

LITTLE WOMEN. This is one of the most delightful books for girls ever written. The girls are very amusing types, and their experiences are told in a way which appeals to all. The character of Jo is drawn very vividly, and we grow to love the girl who manages to get into so many scrapes and then get out of them cleverly.

LITTLE WOMEN WEDDED. This is a continuation of the life of "Little Women." Meg, happily married at the beginning of the book, experiences the many trials and amusing difficulties of a young wife. As the book draws to a close we see the "Little Women" changed into "Good Wives" and all ends happily.

LITTLE MEN. The further experiences of Jo are related in this entertaining book, for she sets up a school for poor neglected boys. Although a hard task, she and Professor Bhaer manage it well, and the boys all thought of "Mother" and "Father" Bhaer with thankful hearts. Of course, the lads get into scrapes, which helps to make the book most amusing.

UNDER THE LILACS. Ben and his dog Sancho run away from a circus and find a home with Bob and Betty in the old house under the lilacs, and his many adventures there with the children are described with humour and sympathy in Miss Alcott's typical style.

AN OLD-FASHIONED GIRL. A delightful study of a healthy country girl, who goes to stay with rich friends. Everybody learns to love her for her charm and unselfishness, and she proves a helpful person when her friends become bankrupt. She eventually marries the son and all ends happily.

EIGHT COUSINS. This is the story of a little girl, Rose, who has lost both her parents, and who goes to live with her aunts and seven boy cousins. Her Uncle Max, a breezy sea captain, who is also her guardian, and herself, are two very lovable characters.

ROSE IN BLOOM. The further story of "Rose." The charming bud of a girl blooms out into a beautiful and lovable maiden, the friend, the peacemaker, the beloved of all—especially of the one with whom she finds happiness.

JO'S BOYS. This delightful story deals with the "Little Men" when they grow up. The irrepressible Tommy Bangs still gets into his scrapes. Jo's own children help towards the making of the book, and in Teddy one can see the old Jo of "Little Women."

AUNT JO'S SCRAP-BAG AND SHAWL STRAPS. The Scrap-Bag is a real treasure house, and "Shawl-Straps" a delightful account of the run through Europe of a party of charming American girls. Brittany, France, Switzerland, Italy, are all pleasantly and cleverly treated, whimsical adventures told, and we get a quaint picture of London in the days of our mothers.

SILVER PITCHERS. Eight stories in Miss Alcott's best vein; jolly girls and equally jolly boys, full of life and spirits and delightful to spend an evening with. Letty's Tramp is particularly good, and Letty as tender as the Tramp is strong and true.

JACK AND JILL. A vivid portrayal of the home and school life of Jack and Jill, and their friends in a New England village. Jack and Jill commence with a spill but Jack soon recovers, though Jill is badly injured. However, with other children, they have a gloriously happy time doing all manner of interesting things.

R. D. Blackmore

LORNA DOONE. The Right Honourable Tom Shaw, writing in 1914 upon "Books That Have Helped me," said: "When I have seen and felt too much of the seamy side, I have always a friend who will help. 'Lorna Doone' will carry me to sweet meadows and wholesome country life, to deeds of modest courage and high endeavour."

Nancy Delves

THE FOURTH FORM. Mona Rhodes begins her life at school by hating and quarrelling with her popular cousin, Allison, but Nonie Shields the merry madcap of the Fourth Form becomes her inseparable chum, and Mona enters with zest into Nonie's hilarious schemes. Nonie is determined that the cousins shall be friends and at last the two are united, much to the delight of their chums.

WELL PLAYED SCOTTS. A fine story dealing with the struggle Micky Quellan and Audrey Harvard had to pull Scotts back to its old position of Cock House of Beverley College. Tennis, Cricket, Athletics, Swimming, Rambles, Picnics, and all the other things that make the summer term the jolliest of the year are here.

Irene Mossop

CHRIS IN COMMAND. Two sisters, Keith and Rosalie Renford, are forced, owing to lack of money, to leave an expensive school and to go to a day school. Chris is the games captain at the school who has a very difficult job, owing to the fact the school is all split up into various leagues. She does succeed in the end. There is plenty of sport and excitement in this fine story of life at a girls' school.

SYLVIA SWAYS THE SCHOOL. Pauline, the leader of the old girls, decides that the new girls must be made to obey the tradition of "Jo's" and kept in a secondary position in the school. But she did not know Sylvia Dare, who by her unfailing good humour, sportsmanship and unselfishness won for the new-comers the respect of all.

PRUNELLA PLAYS THE GAME. Prunella Prendergast was quite unlike the orthodox nervous new girl, and although her elder cousin welcomed her arrival, her younger cousin was jealous of her success at work and games. But the way in which she played the game, won her formmates' hearts and at the end of her first term one and all voted her a "good sport."

NICKY, NEW GIRL. It tells of Diamond Kenley, the captain of the Vikings House at St. Hilary's School and her young sister, Monica (Nicky, for short). Diamond is very jealous of her young sister, whom she regards as likely to supplant her in popularity. The story describes the rivalry between the sisters and is chock full of excitement and sport.

Mary Louise Parker

'MISS SPITFIRE' AT SCHOOL. "Miss Spitfire," or to be exact, Gay Hamilton, is a character that all readers will love. The story of her life at Rolsham Manor School and how she overcomes her unpopularity will appeal to all girls. This book is packed with excitement, fun and sport.

Marie Louise Parker

THE GIRLS OF ST. HILDA'S. Coming back from the Easter holidays, the girls found that their much loved and admired Captain was on her way to Canada for good. This causes great excitement as an election for a new captain has been decided. The result, however, is not satisfactory to all, but the new captain has many staunch pals and in the end wins through.

DIANA AND PAM—CHUMS. When Diana Templeton realised her heart's desire and went to school, she found Pam Weybridge just the chum she had been hoping to find. They were a gay-hearted pair of inseparables, and girls will much enjoy reading about the doings of themselves and their many friends.

A. E. Seymour

A SCHOOLGIRL'S SECRET. This is a story of a girl who paid for her own schooling by writing short stories. She had promised not to reveal her secret, and had to endure a good deal from the curiosity of the girls and the suspicion and measures of some of them. But she had some good staunch friends who stuck to her through thick and thin.

BOYS' BOOKS, 2/6 *net.*

R. M. Ballantyne

THE YOUNG FUR TRADERS. When he was a boy, sixteen years of age, Robert Michael Ballantyne was employed as a clerk by the Hudson Bay Fur Company. He went into Canada, to Rupert's Land, the name given on the formation of the Hudson Bay Company, in the year 1670, by Prince Rupert.

THE CORAL ISLAND. One of the finest boys' stories ever written. The thrilling and joyous adventures of the castaways, Ralph, Jack, and Peterkin on their romantic desert island will never be forgotten. No boy's reading is complete before he has discovered Ballantyne's wonderful yarn.

MARTIN RATTLER. Many of the adventures in this story befall the hero in the romantic forests of Brazil; but before these experiences there come a sea voyage, an encounter with pirates, a wreck, and other thrilling incidents. It has always been a favourite book with boys.

R. L. Bellamy

THE ADVENTURES OF SCOUT GREY. Scout Grey was a scout of the first water. He was more than a scout, he was also a clever amateur detective; and his pluck and ingenuity in unmasking "wrong 'uns," to say nothing of breathless adventures, will delight all boys, whether they are scouts or not.

SCOUT GREY: DETECTIVE. There is a baffling mystery about beautiful old Barnett Farm that nobody can unravel, and is the cause of a whole party of holiday guests having to leave precipitately. But Scout Grey is not easily scared, and stays on to solve the mystery once and for all.

Lucien Biart

FROM LABRADOR TO MEXICO. This story takes us into many lands, among all kinds of interesting and strange people. The young man had anything but a dull time, and encountered a great variety of experiences and adventures.

H. Turing Bruce

THE SCOURGE OF THE MOORS. Raoulf de Gyssage is a hunchback. When he is about 15 he sees his brother killed in a duel by one, Sir Nigel de Flers, and vows to be avenged on the slayer. He runs away from home, goes to the wars, and has many a marvellous adventure.

Harcourt Burrage

THREE CHUMS. The three inseparables were disgruntled because they had been moved from the cock house to a new house, and determined to slack both in work and games. But they grew sick of idling, and the new term found them inwardly rather ashamed of themselves.

D. M. Callow

TOBY IN THE SOUTH SEAS. Toby and Jerry were twins who went to live on a South Sea island with their parents and two sisters. The whole family fairly revelled in the very different life, and the adventures of the two boys make very exciting and interesting reading.

F. Carlton-Wiseman

ONE EXCITING TERM. And a truly thrilling term it was, with enough excitement to last most boys a lifetime. Boy Scouts (and all other lads, too) will revel in this story of mystery and pluck and adventure.

Harry Collingwood

UNDER THE METEOR FLAG. Ralph, the hero, is one of the most dashing midshipmen who ever breathed. His adventures on secret service among the Corsicans and French, and his cuteness in surprising forts and warships lead to early promotion.

George Cupples

THE GREEN HAND. Starting as a very green hand, he soon became as smart as paint. Later, when sailing as a passenger, he takes command in an emergency, and returns home in charge of a prize captured by himself.

Chas. Edwardes

THE NEW HOUSEMASTER. Who was he ? The boys didn't know, nor the headmaster, nor the police. But the gang of coiners knew, and used the boarding school to cover their operations. Eventually they made good their escape. How was it done ?

H. Elrington

THE OUTSIDE HOUSE. Harry Vereker's father having died, his rather mean uncle sends him to a big public school, but enters him at "Pugsleys." It is in rather bad odour, and most of its members feel themselves despised by the rest of the school, who call them "Pugsley's Paupers." But Harry brings a new spirit into it, and the story of how the outside house "makes good" is very interesting reading.

R. A. H. Goodyear

ALL OUT FOR THE SCHOOL. Much fun is caused by the arrival at Wolverton School of twin masters, who add zest to the life of the school. There is much fun in this tale and some stirring accounts of Soccer matches. Mr. Mellowship, a master known as "Ship Ahoy!" is most popular and proves a marvellous football coach.

STRICKLAND OF THE SIXTH. Owing to its comparative inaccessibility on top of a hill, Hanenhall School has fallen on bad days, there being only about a quarter of the number of boys it could accommodate. But "Strick," the captain, determines to make things hum. How he does it so that three hundred new boys are expected by the next term is a very interesting story.

THE HARDY BROCKDALE BOYS. Brockdale is proud of being known as one of the most robust public-schools in the country. It looks down with pitying contempt on a neighbouring school of delicate boys. Healthy sport and bright doings at Brockdale are spiced by a series of mysterious adventures, and a way is found in the end by which the Brockdale boys may meet the once-despised school on level terms.

J. Percy Groves

CHARMOUTH GRANGE. Philip Ruddock was a truly villainous villain. He caused his old kinsman to be poisoned, and tried his best to do away with the young heir so that he himself might own Charmouth Grange. But young Ronald Cathcart, with tremendous pluck (and no little luck), came into his own after many vicissitudes and hair-raising adventures.

Bernard Heldman

MUTINY ON BOARD THE "LEANDER". This book is packed with thrills of all kinds. The men of the "Leander" were a pretty rough lot, but their "coup" brought no good either to themselves or the few honest men on board. Fire, shipwreck, savages, pirates, slavery, and final escape all tend to make breathless interest for boy-readers.

G. A. Henty

THE CORNET OF HORSE. This fine story of the gallant days of old, traces the career of the hero from his first lesson in fencing until he becomes one of the finest swordsmen in Europe. He ruffles it with Marlborough in England, France and Germany.

JACK ARCHER. A midshipman in the Crimean War is captured by brigands at Gibraltar and held to ransom, but escapes. He takes part with a Naval Division at Balaclava and covers himself with glory.

WINNING HIS SPURS. The story of an English lad who won his spurs after many wonderful deeds and hairbreadth escapes during the Crusades. Not dry history, but a series of glorious adventures.

Kit Higson

THAT SURPRISING BOY, SPINKS. They were a jolly lot of youngsters, but harried by a big bully, until "that surprising boy" arrived; and the *most* surprised person was the bully, who found he had met his match. Jimmy Spinks and his special chum, Jack Taylor, are two fine little chaps, and their adventures will delight boys.

George Gibbard Jackson

THE QUEST OF THE OSPREY. The story of the hunt for a mine of fabulous value, both an English captain and a Frenchman being very keen. Two boys who stowed away on the Englishman's ship come in for any amount of excitement and danger and adventure. A thrilling story for boys.

Arthur L. Knight

IN JUNGLE AND KRAAL. The adventures of two young midshipmen in the jungles of Ceylon. Immediately on landing at Colombo from their ship, they fall into thrilling adventures, lose their horses and nearly their lives! An expedition into the jungle is planned, and, after many adventures they assist in the capturing alive of a herd of elephants.

Andrie Laurie

THE CRYSTAL CITY. "The Crystal City" is a fantastic tale of a young midshipman, who, washed overboard in a storm, finds himself in a wonderful glass city under the sea; its only occupants being an old man and his beautiful daughter. The mystery of their existence there, and the result of the young sailor's visit make a very interesting story.

J. Macgregor

ONE THOUSAND MILES IN THE ROB ROY CANOE. This is the log of a charming cruise in a small canoe, designed by the writer. With paddle and sails he traversed the rivers Thames, Sambre, Meuse, Rhine, Main, Danube, Aar, Ill, Moselle, Meurthe, Marne and Seine, and Lakes Titisee, Constance, Unter See, Zurich, Zug, and Lucerne, together with six canals in Belgium and France, and had two expeditions in the open sea of the British Channel.

Peter Mael

UNDER THE SEA TO THE NORTH POLE. A thrilling story of adventure in the Arctic regions, with hardships galore met with pluck and endurance. Mutiny and treachery have their part, and strenuous fights with polar bears, and dangers of all kinds.

Captain Marryat

MR. MIDSHIPMAN EASY. Before he began to write books, Captain Marryat had a share in many hard-fought battles at sea. He sailed as a midshipman under Lord Cochrane, and spent years in dangerous service off the French and Spanish coasts. Marryat served many years after this, and was the hero of many exploits that had been embodied in his works. Critics agree that "Mr. Midshipman Easy" ranks among Marryat's very best.

Herman Melville

MOBY DICK. Here we have a moving book which could have been written only by a writer of genius who had lived a life of peril. Such incidents as these could not have been invented. Herman Melville went upon a whaling expedition, and we have the result in these stirring pages. The sense of reality is wonderful, and the tale made the writer famous all over the world. It is now a classic.

Sam Noble

'TWEEN DECKS IN THE 'SEVENTIES. A book that any boy worth calling a boy will delight to read and have for his own. It is a truly fascinating account of life in the Navy when Sam Noble was young. Simply yet forcefully written, every line is a joy.

G. Norway

RALPH DENHAM'S ADVENTURES. A tale of the Burmese jungle. A boy sets out from his home to take up work in Burma. His adventures begin early, for his boat catches fire and sinks. The firm for whom he was to work in Burma fails, and he is cast upon his luck. He travels through the jungle, has many adventures, and finally makes good.

Michael Poole

UNDER RINGWOOD'S RULE. Jackson Wrexham, the son of an American millionaire, is sent to Ringwood School where he strongly resents the discipline imposed and quite fails to understand the team spirit. He has a great number of scrapes and even tries to run away from school. Eventually, being a good swimmer, he wins an event for the school and at last settles down happily.

Louis Rousselet

THE SERPENT CHARMER. A French gentleman and his boy and girl fall under the displeasure and into the power of a great Indian Prince. Andre, the son, escapes, and disguised as a young native has many adventures, and is finally reunited with his family.

J. G. Rowe

ROUND THE WORLD WITH DRAKE. A story of Sir Francis Drake's voyage round the world in "The Golden Hind," of the voyages, many and adventures, victories with the Spaniards, endurance, of storms and hardships and triumphant return to Plymouth, to say nothing of the special exploits of a charming young hero.

W. Clark Russell

THE FROZEN PIRATE. Paul, a sole survivor, finds, stuck fast in the ice, an old ship. On board is the frozen form of an eighteenth century pirate, whom Paul brings back to life for a while, and eventually gets both ship and treasure home intact.

THE SEA QUEEN. A tale of the sea and seafaring people, told by a girl, Jessie, who married Richard, a captain, and goes with him on an adventurous voyage. It includes a mutiny, a ship on fire, and the wonderful salving of another vessel that provides them with an ample reward.

W. Clark Russell

THE WRECK OF THE "GROSVENOR". Recognised as one of the greatest stories ever written. The unforgettable story of the mutiny on the "Grosvenor," out from England, the sailing of the mutineers for Florida, how the hero, with a couple of seamen, tricks them and takes the "Grosvenor" along till she sinks, the taking to the boats, and the final rescue.

A SAILOR'S SWEETHEART. Will goes off on his last voyage before becoming first mate. Unknown to him his sweetheart Nellie books a passage by the same boat. The captain goes mad and hangs himself, whilst Will, Nellie, and three sailors, are wrecked, but manage to bring home a valuable waterlogged vessel.

JACK'S COURTSHIP. Jack's girl friend is sent on a voyage. Disguised, he sails in the same ship. His rival is no sailor, and leaves the ship in disgrace. In dire peril, Jack takes charge so capably that he overcomes all opposition and wins his bride.

Michael Scott

TOM CRINGLE'S LOG. The author of these moving adventures was a University man who went to Jamaica and the West Indies as a planter. By his keen observation he collected the materials that he used in this sprightly book. The book is packed with incident, the style is lively and full of fire, so that this story has remained very popular ever since its appearance in 1833.

Jules Verne

THE ABANDONED. This is the story of the mysterious island upon which the castaways were "Dropped from the Clouds" and also the story of a neighbouring island that proved even more of a mystery. On this second island they find "The Abandoned," a man with a strange history, which the story relates.

ADRIFT IN THE PACIFIC. Just the book for boys! A party of school boys suddenly find themselves adrift on the mighty ocean. They are wrecked on a lonely island. How do they fare? What can they do? Read how they set up a little colony and governed it, how they hunted, fished, explored and finally overcame some murderous mutineers thrown ashore on the coast of their little island.

AROUND THE WORLD IN EIGHTY DAYS. Phineas Fogg, for a wager, attempts to make a circuit of the earth in eighty days. It is a case of whirlwind travel, and the story of the journey goes along with a rush of excitement. Adventures crowd upon Phineas ashore and afloat, enemies try to thwart him, accidents delay him, and he returns to London just too late, and yet in time! Therein lies a puzzle.

THE CLIPPER OF THE CLOUDS. The most wonderful aeroplane that ever navigated the air, and yet it was invented in Verne's magical brain long before the first airman set his propeller whirling. Captain Robur does what no airman can do to-day, and the story of this world-wide voyage is one continuous thrill.

THE CRYPTOGRAM. This was the secret document, written in a difficult cypher, which proclaimed the innocence of Joam Dacosta, a man condemned to death for a crime of which he was innocent. The story of the trial and the unravelling of the "Cryptogram" at the last moment makes an enthralling story.

Jules Verne

DROPPED FROM THE CLOUDS. Five men escaping by balloon from an American city in war-time, are carried out to sea by a hurricane. After the most acute perils they are cast upon a island far from land. Here the heroes settle, and provide themselves with clothes, food, weapons by a clever use of the natural products of their new home.

FLOATING ISLAND. An artificial island, four and a half miles long and three broad, is made by an American multi-millionaire. It contains mansions, parks, public buildings, water supply, etc. Moved under its own power, it travels to many parts of the world. The marvellous adventures of its inhabitants make an exciting story.

THE FUR COUNTRY. An exciting story of the wonderful land of the Midnight Sun. It tells of the perils and excitement of trapping in the Arctic Circle, and the hunting of wapiti and polar bears and silver fox, etc., varied with adventures among icebergs and the great rivers and lakes of the Fur Country.

THE MASTER OF THE WORLD. "Robin the Conqueror" he calls himself, because he considers that the wonderful flying machine he has invented and constructed gives him complete control of the destinies of all nations. But he comes up against John Stock and finds he is not so powerful as he thought he was.

FROM THE EARTH TO THE MOON AND A TRIP ROUND IT. An American determined to pay a visit to the moon; so he built an enormous gun, and a house like a shell, and tried. The results of his experiments are contained in this astonishing book.

GODFREY MORGAN. Godfrey Morgan has everything a young man can want, but he is weary of luxury and longs for adventure. His fond uncle allows him to go off on a voyage with his tutor, a most egregious fool. The ship sinks under them, and the two are thrown upon an island, and have just as much adventure and hardship as they can put up with.

EIGHT HUNDRED LEAGUES ON THE AMAZON. Not merely a description of a journey down the most wonderful river in the world, but the story of a brave gentleman wrongfully accused of a crime, and the schemes of a rascally adventurer to blackmail him and his family.

A FLOATING CITY & THE BLOCKADE RUNNERS. "The Blockade Runners" tells how a grave and handsome young skipper ran a cargo to the American ports during the Civil War, and how he had on board a winning little lady, so that he not only ran a cargo, but brought away an imprisoned father condemned to death, and so won himself a charming bride.

THE ADVENTURES OF THREE ENGLISHMEN AND THREE RUSSIANS. Three Englishmen and three Russians go on a joint scientific and exploring expedition to South Africa. They disagree and separate; natives attack them, and only after many perils do they re-unite in safety.

FIVE WEEKS IN A BALLOON. In a balloon, which had something of the airship about it, the inventor, his faithful servant, and a friend, cross Africa from East to West. Swamps, forests, deserts, savages, fierce beasts, hunger and thirst all assail the intrepid voyagers in turn; but they win through by skill, pluck and endurance.

Jules Verne

TRIBULATIONS OF A CHINAMAN. A rich young Chinaman, finding the future does not attract him, writes an order to his friend to kill him, choosing his own time and method. He then changes his mind and wants to live, but friend and paper have both disappeared, and a wild goose chase with endless set-backs follow.

TWENTY THOUSAND LEAGUES UNDER THE SEA. The masterpiece of all submarines was the one imagined by Jules Verne and constructed by Captain Nemo, the most mysterious sailor that ever sailed the sea. The voyages of this book and the astounding adventures of its crew make it one of the most fascinating stories ever published.

DICK SANDS. When a catastrophe deprives a sailing ship of its captain and nearly all the crew, the responsibility of bringing the ship safely to the end of its voyage devolves upon Dick Sands, a boy of fifteen. He does his best, but treachery results in landing them in Africa instead of the haven they desired, and many adventures befall him and his party.

THE END OF NANA SAHIB. A story of the time a few years after the Indian Mutiny. A party of men travel many miles in a wonderful moving house, drawn by a marvellous steam elephant. Their many adventures and the doings of Nana Sahib, the fiend of the Mutiny, and his final overthrow are very exciting.

THE FLIGHT TO FRANCE. An interesting story of a party of charming French people who are forced to flee from Germany when war is declared between the two countries. They pass through many vicissitudes on the journey. One of their number comes within an ace of being "shot at dawn."

HECTOR SERVADAC. A most astonishing story of the collision between a comet and the earth, full of adventure and excitement, and incidentally, full of information concerning certain heavenly bodies.

THE VANISHED DIAMOND. A fine story of the South African diamond fields and the adventures of a young engineer who attempted the dangerous experiment of trying to make a diamond. There was a diamond and it vanished; but how? Read the story.

THE SECRET OF THE ISLAND. This is a story of mystery, an unseen man who guards the castaways and provides for them. Their attempts to discover the secret are in vain, but at last the Unknown reveals himself as Captain Nemo, the hero of "Twenty Thousand Leagues Under the Sea."

WINTER AMID THE ICE. An ice-bound ship, two deadly enemies aboard, shortness of food, fights with men and polar bears, dangers of every kind possible in the Arctic Circle make an exciting and interesting book for boys and others.

THEIR ISLAND HOME. Jules Verne had such an admiration for the famous book, "The Swiss Family Robinson," that he himself wrote a sequel, and carries the history of the Zermatts considerably further. The book is at least as interesting as the one that inspired it.

THE CASTAWAYS OF THE FLAG. The final adventures of "The Swiss Family Robinson." Here some of the family having visited Europe are on their way back to their island home when they are shipwrecked. After many privations and adventures they get a very pleasant surprise.

Jules Verne

THE LIGHTHOUSE AT THE END OF THE WORLD. Three men are left in charge of a new lighthouse on a lonely island at the southern extremity of South America. A band of pirates have a lair near-by and most exciting happenings take place.

MICHAEL STROGOFF. The greatest romantic writer since Alexandre Dumas, Jules Verne's works have been translated into every language. Michael Strogoff is ranked by critics as one of the finest creations of his pen.

THE MYSTERY OF THE FRANKLYN. The story of Captain John Branican, who set sail for a voyage to the East, expecting to return to his home in six months. But he did nothing of the kind. The story of the various efforts to discover what had happened to him and his ship, with the final unmasking of a villain, will greatly interest boys.

Rowland Walker

THE LOST EXPEDITION. Two boys are allowed to go with a party to search for the members of an expedition that has been lost in the wilds of the Amazonian forests. They have glorious adventures and narrow escapes galore, but all ends well.

MASTER VALENTINE BUCKET. Valentine Bucket was a new boy, but not the ordinary retiring sort of new boy. They all thought at first, that he was a "lout" and a "mug-wump," but he soon showed he was nothing of the sort, and made the whole school "sit up and take notice" from the "Dominus" downwards, especially the school bully.

Lew Wallace

BEN HUR. A tale of Christ. The story tells of the experiences of Ben Hur in the East at the time of the birth of Christ, and the beginnings of Christianity. The tale is written in absorbing style and the daily life and atmosphere of the time are powerfully depicted.

GIRLS' SCHOOL STORIES

AND TALES OF ADVENTURE, 2/- *net.*

Louisa M. Alcott

LITTLE WOMEN. This is one of the most delightfully homelike books for girls which have ever been written. The character of Jo is drawn very vividly, and we all grow to love the tom-boyish girl who manages to get into so many scrapes and awkward positions and then get out of them cleverly.

LITTLE WOMEN WEDDED. This is a continuation of the life of "Little Women." Meg, happily married at the beginning of the book, experiences the many trials and amusing difficulties of a young wife. As the book draws to a close we see the "Little Women" changed into "Good Wives" and all ends happily.

Marjorie Bevan

FIVE OF THE FOURTH. A very merry little quartette were gathered in the Recreation Room on the first day of the Summer Term; and in discussing their plans were quite determined that no one should be allowed to share, or spoil, their companionship. But Peggy Lawson, a new, shy girl, intrudes, with the result that they have more fun and adventures than ever.

THE PRIORY LEAGUE. The old school is in danger of being sold because there is no money for repairs. There is an old legend that when the Danes invaded England and sacked the Priory, the founder had hidden some of her treasures. Several of the girls band themselves into a "League," determined to find the long-lost riches. Their adventures and what happened in the end make a truly exciting story.

Jennie Chappell

AILSA'S CHUM. A deeply-moving girl's story. Life proceeds happily and unevenly in the Brereton household until there comes a railway accident and a strange baby is thrust upon the family. Soon after complications begin, and a fine story is unravelled. The story closes with the reunion of two lovers long parted and lost to one another through misunderstanding.

GLADWYN. This book is described by the author as "a circle of fortune," and concerns the adventures of Gladwyn, heiress to a worthless estate. How she faces his difficulties and goes to London and finally finds much love and happiness is told with a swinging style.

M. De Witt

AN ONLY SISTER. Elizabeth and Marc, and Pierre and Henri, were the children of a French gentleman who fell on evil times. After his death the four had a desperate struggle to live, and it was the sister who bore the heaviest burden. But fortune smiled on them at last.

Enid Leigh Hunt

HAZELHURST. Here you have the story of a charming "nut-brown mayde," the youngest of a family, the others all being boys; a delightful group of brothers, who make much of their young sister. There is also someone else, *not* a brother, but equally delightful and interesting. A book to charm and delight all girls.

THE ADVENT OF ARTHUR. Joyce Dayrell and her brother, Jocelyn, in the absence of their father abroad, have to live with relations, who are hard and unsympathetic. Sister and brother decide to go away and fend for themselves. Joyce becomes a teacher in a school, but life is often hard and dreary—until "Arthur" comes.

Bertha Leonard

THE HOUSE OF DOUG. Judith Douglas is the middle member of a lively, rollicking family. Full of life and spirit, and mischief, she is an incorrigible tease, but adored by all the others. There is tremendous excitement when their father inherits a lovely old mansion, with old oak, ancestral portraits, traditions and ghost all complete.

Bessie Marchant

CICELY FROME. The story of a girl, who, a captain's daughter, learns early in life that her father is missing. She goes to Ceylon and has many enthralling adventures, the chief of which is the tracing and rescuing of a stolen baby. Finally, the mystery surrounding her father's disappearance is cleared up.

Irene Mossop

WELL PLAYED, JULIANA! Juliana thoroughly enjoyed her first term at school and made good both at work and games. She was beautiful and charming and very wealthy—her chief friend was a scholarship girl who had no money and no pretty clothes. In the end an exciting secret was discovered that brought them much happiness.

PRUNELLA PLAYS THE GAME. Prunella Prendergast was quite unlike the orthodox nervous new girl, and although her elder cousin welcomed her arrival, her younger cousin was jealous of her success at work and games. But the way in which she played the game, won her form-mates' hearts and at the end of her first term one and all voted her a "good sport."

Mrs. Herbert Martin

THE LONELIEST GIRL IN THE SCHOOL. The story of the Princess Ottilia, who comes from abroad to live at an English school while her father is travelling. Shy and reserved by nature she soon becomes "the loneliest girl in the school."

Sibyl B. Owsley

DULCIE CAPTAINS THE SCHOOL. The story of a shy, diffident girl who was not at all happy when circumstances made her captain. But she faced her difficulties with pluck and came through her dreaded ordeal with flying colours and won the love and respect of the whole school.

Mary Louise Parker

PAT OF THE FIFTH. A quite delightful story of schoolgirl life. Pat O'Farrell is really rather a dear and attracts the love of most people she meets, old and young. Girls will enjoy reading about her adventures and the doings of herself and her friends, both boys and girls.

MOLLIE OF ST. MILDRED'S. Mollie Winfield was one of a family; Chris. Carstairs was an only child, and somewhat spoilt. Both arrived at St. Mildred's, and girls will enjoy reading about their friendships and their work and their play, and their prowess in games and sport generally.

H. B. Stowe

UNCLE TOM'S CABIN. People who were not alive in 1851, when "Uncle Tom's Cabin" was written, will not be able to understand the great excitement caused by this book, both in England and in America; and when the struggle between those who wished to abolish slavery and those who desired to perpetuate it resulted in the American Civil War.

Mabel L. Tyrrell

THE FORTUNES OF THE BRAITHWAITS. A family of four, three girls and a boy, live with an aunt, their parents having died. Their new neighbours at the old Manor House are a source of great interest to them. A most mysterious burglary, the disappearance of Henrietta, are a few among the exciting incidents.

VICTORIA'S FIRST TERM. Victoria Alberta Mackain begins her school life all wrong, and gets out of favour with nearly all the girls, to say nothing of worrying the headmistress. But she soon finds her own place and ends by being recognised as a "real sport."

A. D. T. Whitney

A HEART OF GOLD. Home life in a New England country place; quiet, Puritan folk, living out their lives in traditional manner. The main characters are two girls, one a pessimist and the other an optimist.

OTHER GIRLS. Sylvie Argenter made the discovery that "other girls," girls belonging to other circles, had hearts too. When adversity came to herself, she faced it bravely, and in the end had her reward.

WE GIRLS. The story of healthy, happy life among a family of girls and their friends. Such a cheery crowd they are, in spite of not being blessed with too much of this world's goods. Everybody is glad when a missing paper turns up in a strange way, which ensures that they will not have to leave the old house they all love.

May Wynne

CAROL OF HOLLYDENE SCHOOL. A delightful school story, full of pranks and games and high spirits. There is also a mystery which sets the tongues of the unpleasant set wagging against Carol, but her special chums are loyal and all ends well.

BOYS' SCHOOL AND ADVENTURE SERIES, 2/- *net.*

Harold Avery

A BOY ALL OVER. Fred and Bob, two school chums, who are by no means namby-pambies, have many escapades, but come out on top, largely owing to the hero's sister, who proves a good pal to both.

Tom Bevan

THE HEROIC IMPOSTOR. Henry Borden was an impostor; he took another man's name and place, but how could he help it; so much happiness for other people depended on it. Full of intrigue and danger and tight corners, this book will entrance all boys who *are* boys.

BOB BLAIR—PLAINSMAN. Bob Blair, riding back to his homestead in Australia one day, finds it burnt to the ground, and all his stock stolen. The story of the struggle between Bob, supported by his friends, and Sandy Malone, the bushranger, and his followers is cramfull of thrills.

THE MYSTERY TRAIL. Becoming separated from his party while out on an expedition, Ronald Leslie is surrounded by black men, bound and gagged, and carried away. To his amazement he finds that he has been kidnapped by order of a white man, who is a kind of king in the wild country.

Harry Collingwood

THE WRECK OF THE "ANDROMEDA." A thrilling story of a shipwrecked party, who land on a wonderful island, where strange things happen to them. The moving spirit amongst them is young Massey, one of the ship's officers, whom all boys (and others) will much admire.

THE CRUISE OF THE "FLYING-FISH." The wonder ship that flies high in the air, skims the surface of the sea, and descends to its lowest depths. Its owners hide it under the waters of the English Channel until they need it for their cruise. Their dismay when they discover it has been stolen, and their adventures in recovering it, make an exciting story.

IN SEARCH OF EL DORADO. Wilfred Earle, an American, and Dick Cavendish, an Englishman, set out on an expedition to try and discover the "fabled city" of Manoa, the city of El Dorado. They have the most thrilling adventures, and make the most surprising discoveries.

UNDER A FOREIGN FLAG. The Story of Paul Swinburne, a middy who, through the machinations of his cousin, is court-martialled and dismissed the Service. He joins the navy belonging to another country, and after seeing much fighting, and having many adventures his innocence is established. A fine racy story.

THE VOYAGE OF THE "AURORA." Having suffered a keen disappointment, young Captain George Leicester bought the "Aurora" with his savings and set out on a voyage to Jamaica. He had hair-raising adventures before he got there, and if he wanted something to distract his mind, he most certainly got it.

Harry Collingwood & Percival Lancaster

IN THE POWER OF THE ENEMY. Hugh Marchmont is devoted to his little brother Jack. During trouble with the Zulus the child is stolen by Hugh's arch-enemy and given to the black warriors. The wildest, most hair-raising adventures happen to both brothers before Hugh succeeds in saving the child.

W. Bourne Cooke

THE GREY WIZARD. A thrilling pirate story, with a kidnapped boy, a secret concerning hidden treasure, a truly poisonous villain, treachery, pluck, and a happy ending, all the ingredients for a thoroughly enjoyable boy's story.

J. Fenimore Cooper

TWO ADMIRALS. A vivid story of sea-fighting, in which the two admirals, who had been almost life-long friends, find themselves out of sympathy with one another concerning the Jacobite cause. However, in time of stress and danger, friendship proves stronger than opinions.

G. Manville Fenn

THE BLACK BAR. Two great chums are midshipmen on a vessel fighting the slave traders. Bob provides all sorts of fun, and Mark, after many desperate escapades, captures two slave-ships, and gains heaps of prize-money for all concerned.

G. Manville Fenn

OFF TO THE WILDS. Two boys are first taught shooting by their father and are bought all sorts of equipment. Taken hunting, they bag every sort of animal—lions, rhinos, elephants, giraffes, etc. Dinny, an Irish retainer, keeps everybody jolly.

FIRE ISLAND. The adventures of a cheery ship's crew among Papuan savages. Cast high and dry by a tidal wave upon the shore of a volcanic island, they find it a veritable hunter's paradise. Plenty of fun and adventure.

THE SILVER CAÑON. Lascelles makes a powerful friend by curing an Indian chief named "Beaver" of an arrow wound, and in return he is shown the Silver Cañon containing wealth untold. Adventures with bison, bears and rattlesnakes, and a terrific ride on the wonderful horse "Black Boy" make up a splendid story.

R. A. H. Goodyear

BOYS OF THE MYSTERY SCHOOL. A story full of thrills and containing a particularly intriguing mystery. There is also a feud with a neighbouring school in which our friends of the Mystery School come off best, and fine descriptions of football and cricket games. A very good story for boys.

THE SPORTING FIFTH AT RIPLEY'S. A rattling schoolboy story, with some delightful youngsters, the inevitable mischief-maker, and fine descriptions of battles on the playing fields. . . . A book to engross the attention of all sports-loving schoolboys.

THE FELLOWS OF TEN TREES SCHOOL. Nearly everybody resented "Jig" being a member of the School. The decent boys ignored him and the bullies made his life there a misery. But, in the end, his pluck and patience and steady endurance won him the respect of masters and boys alike.

G. Forsyth Grant

BURKE'S CHUM. The adventures at Thistleton School of Burke and his chum, Percival, told in a lively manner. The story is full of adventurous doing and thrilling exploits. The author understands boys, and gives them the kind of stuff they like.

THE BERESFORD BOYS. Wilmot, of Beresford School, is accused of breaking school regulations, and his stubborn assertions of innocence only serve to harden opposition. After an obstinate time, he has an opportunity of helping his master save his new book from fire, disports himself generally like a hero, and clears his character entirely.

THE BOYS OF PENROHN. The school life and adventures at Penrohn School of two brothers. The boys enter school under a cloud of sorrow, which is intensified for Atholl by happenings to his brother. Further trouble for Atholl results. Soon, however, the facts come to light and we leave Atholl happy and popular at Penrohn School.

A. L. Haydon

UP-SCHOOL AT MONKSHALL. Fred Fulton is sent to a fine public school by a "friend" of his father's on condition that he does exactly what he is told to do. Later he finds he must choose between betraying his father or his chum. The book tells how he came out of the ordeal.

Ascott R. Hope

THE BOYS OF WHITMINSTER. This book recounts the adventures and misadventures of as lively a bunch of schoolboys as you could wish to meet. The titles of the sections are : The Favourite, The Burglar, A History of Hampers, The Misfortunes of an Eleven, St. Valentine's Day.

SCHOOLBOY STORIES. Stories about boys for boys by this ever-popular author : scrapes and jokes, adventures and surprises all come into the various stories—eight long ones in all. The stories are written in a bright style and are full of life.

REDSKINS AND SETTLERS. Yarns of life in the Wild West. Many thrilling adventures are recorded in graphic style. The times of Buffalo Bill, and Kit Carson, the times of fierce fighting with Red Indians and with all the perils of a new country, are dealt with in these stories.

THE TRUANT FROM SCHOOL. The story of a boy whose parents have died and left him to the tender mercies of a little backwood's community. He runs away and has exciting times among Red Indians.

Thomas Hughes

TOM BROWN'S SCHOOL-DAYS. This great classic boy's book continues its popularity ; it is the finest of all school stories, and one which every boy must read at some period or other in his boyhood. Your father will tell you how *he* enjoyed it when he was your age.

Cutcliffe Hyne

SANDY CARMICHAEL. Here is a story to gladden the hearts of boys and make their pulses beat. Sandy is a ragged little urchin, who travels far, has many adventures, and so impresses the savages he finds himself among, that they decide to make him king.

Percival Lancaster

CAPTAIN JACK O'HARA, R.N. A rollicking story of a fiery-haired, quick-tempered, but lovable sailor, who has many adventures, who takes all kinds of risks, and is afraid of nothing and no one but the heroine. But, finally, he succeeds there too, as he certainly deserves to.

George Little

LIFE ON THE OCEAN. The thrilling account of twenty years at sea told very vividly. Fights and mutiny, cannibals and pirates, all have their share in making a very exciting and interesting book.

Bessie Marchant

ON THE TRACK. A boy finds while searching in his grandfather's writing-desk strange papers, and a history of treasure gold, telling how his grandfather, many years before, for love of a girl, left England for South America, and found moving adventures and many hard knocks.

Francis Marlow

THE SECRET OF THE SANDHILLS. A most exciting story of hidden treasure. It gives a vivid idea of the rough life on a sailing ship, and tells of treachery, intrigue, wild adventure, and final downfall of the villain-in-chief.

Robert Overton

A SON OF THE SCHOOL. A splendid yarn which will thrill all boys. There are fine accounts of cricket and football matches and more than a spice of adventure. A fine spirit of esprit de corps hangs over the book.

Walter C. Rhoades

OUR FELLOWS AT ST. MARK'S. This is a fine school story. It concerns the adventures of Grayson and his friends at St. Mark's School. All the elements which go to make up a good school story are here : exciting school sports, cricket and football matches, the thrashing of a bully.

W. A. Rogers

DANNY'S PARTNER. An interesting story of the love between a one-legged man and a little orphan boy. It tells of their adventures travelling with a wagon-team out to the wilds, their search for gold, their troubles from horse-thieves, and Red Indians, and final happiness and success.

Rowland Walker

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GIRLS'

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